COMMONWEALTH OF AUSTRALIA

STATE OF QUEENSLAND

REPORT No. 137

Geology of the Charters Towers 1:250,000 Sheet Area, Queensland

BY

D. H. WYATT*, A. G. L. PAINE†, D. E. CLARKE*,
C. M. GREGORY† and R. R. HARDING†

* *Geological Survey of Queensland*
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CONTENTS

CONTENTS (Cont'd)

APPENDICES

CONTENTS (Cont'd)

CONTENTS (Cont'd)

PLATE

SUMMARY

The Charters Towers 1:250,000 Sheet area in northeast Queensland was mapped by the Bureau of Mineral Resources and the Geological Survey of Queensland in 1963-64 and 1966-67.

Charters Towers (population about 8000), near the northern edge of the area, is 80 miles southwest of Townsville, on the railway between Townsville and Mount Isa. The climate is tropical; the average rainfall is between 20 and 30 inches, most of which falls in the wet season between December and April. The area lies within the dissected tableland which forms the eastern fall of the Great Dividing Range. Topographic relief is generally moderate, with extensive plains in the southwest.

Tertiary sediments and laterite cover half the Sheet area, mainly in the south and west. Early Palaeozoic granites occupy about 25 percent of the area, mainly in its northern half. These intrude earlier Palaeozoic sediments and volcanics which occupy a further 10 percent in an east-west belt through the centre of the Sheet. Devonian and Carboniferous sediments of the Drummond Basin cover another 10 percent in the southeast and Permian and Mesozoic sediments of the Galilee Basin some 3 percent in the southwest. Isolated late Palaeozoic granitic and rhyolitic intrusions cover the remaining 2 percent, mainly in the eastern half of the Sheet area.

The oldest rocks are the Cape River Beds, Charters Towers Metamorphics, and Kirk River Beds. All are unfossiliferous but are regarded as Cambrian to Ordovician in age. The Cape River Beds consist of a thick sedimentary sequence and an acid volcanic member, the Mount Windsor Volcanics, which thicken eastwards. They have been contact-metamorphosed by the Ravenswood Granodiorite Complex; in the Hughenden Sheet area they have also been regionally metamorphosed and isotopic dating suggests that here the regional metamorphism is early Ordovician. The Charters Towers Metamorphics consist of schist, quartzite, and hornfels which form roof pendants in the Ravenswood Granodiorite Complex. The Kirk River Beds are an isolated remnant of poorly sorted labile sediments intruded by, and downfaulted into, the same complex. The Ravenswood Granodiorite Complex, which intrudes all these formations, is a large batholith which has a present exposure of 2000 square miles in the Sheet area. Most of it was intruded in the Middle Ordovician, but some masses of Upper Silurian or Lower Devonian age have been detected by isotopic dating. Two named intrusions of Upper Silurian or Lower Devonian age are the Lolworth Igneous Complex and the Barrabas Adamellite. A period of deep and widespread erosion followed, and this serves as a convenient division between the 'early' and 'late' Palaeozoic.

Renewed sedimentation is represented in the southeast by the lower Middle Devonian Ukalunda Beds, a moderately deep water sequence which is fossiliferous in the Bowen Sheet area nearby. The Ukalunda Beds are overlain unconformably by the non-marine sediments and acid volcanics of the Upper Devonian to Lower Carboniferous Drummond Basin (St Anns Formation, unnamed volcanics, and Drummond Group). These heterogeneous sediments were deposited in flood-plains and lakes, and parts of the sequence were derived from the erosion of contemporaneous acid volcanics. The northern margin of the Drummond Basin is a shelf overlying the Ravenswood Granodiorite Complex. The axial zone of the basin has been tightly folded along northeast-trending axes.

The Upper Carboniferous and Lower Permian are represented only by igneous rocks, most of which are intrusive. Scattered outcrops of acid volcanics, broadly correlated with the Upper Carboniferous Bulgonunna Volcanics in the Bowen Sheet area, occur in the northeast; irregular intrusions of rhyolite and porphyry are probably related to the volcanics. Sill-like bodies of altered diorite and gabbro occur in the Drummond Basin. High-level granitic stocks and complexes occur in the north and east. Isotopic ages near

the Carboniferous-Permian boundary have been obtained from the Tuckers Igneous Complex and Boori Igneous Complex, but the Mundic Igneous Complex, which includes minor volcanics, is thought to be Upper Permian. The Upper Permian Betts Creek Beds and the Lower Triassic Warang Sandstone crop out in the southwest of the Sheet area, and dip gently southwest along the margin of the Galilee Basin. Both are freshwater sequences, but they are separated by a slight unconformity. Nearby, in the Hughenden Sheet area, the Betts Creek Beds contain coal measures and minor tuff.

Thin lacustrine and fluviatile Tertiary sediments were deposited in two distinct periods, separated by a period of lateritization. The older Tertiary sediments, which crop out in scattered pockets in the east, centre, and northwest, are regarded as early Tertiary in age. The Campaspe Beds, in the south and west, are younger than the laterite and regarded as Pliocene; they were laid down as disconformable piedmont deposits on the eroded laterite surface and form plains 2500 square miles in extent. The Campaspe Beds have a thin capping of nodular ferricrete. Olivine basalt was erupted in the late Tertiary to Quaternary (Nulla and Toomba Basalts); the Toomba Basalt may be Recent in age.

Charters Towers produced much of Australia's gold in the 1890's and early 1900's; total recorded production is about 6,800,000 fine ounces. By 1920 production had almost ceased, owing to the gradual depletion of the ore with depth in the major mines. A minor revival in 1931 lasted for some 20 years. The gold occurred mainly in quartz lodes in the Ravenswood Granodiorite Complex, and was accompanied by pyrite, galena, and sphalerite. The smaller centre of Ravenswood in the northeast produced some 900,000 fine ounces of gold, which occurred mainly in sulphides. Subordinate quantities of silver, lead, and copper have also been produced in the Sheet area.

INTRODUCTION

The Charters Towers 1:250,000 Sheet area (Fig. 1) is bounded by latitudes 20°S. and 21°S. and by longitudes $145^\circ30'$E. and 147°E. It covers parts of the Charters Towers and Ravenswood Gold and Mineral Fields. This Report describes the regional geology of the Sheet area, which was mapped in 1963-64 by a combined field party (comprising the authors) of the Commonwealth Bureau of Mineral Resources and the Geological Survey of Queensland, and in 1966 by one of the authors as a combined BMR-GSQ 1-mile mapping project (Clarke, 1969, unpubl.).

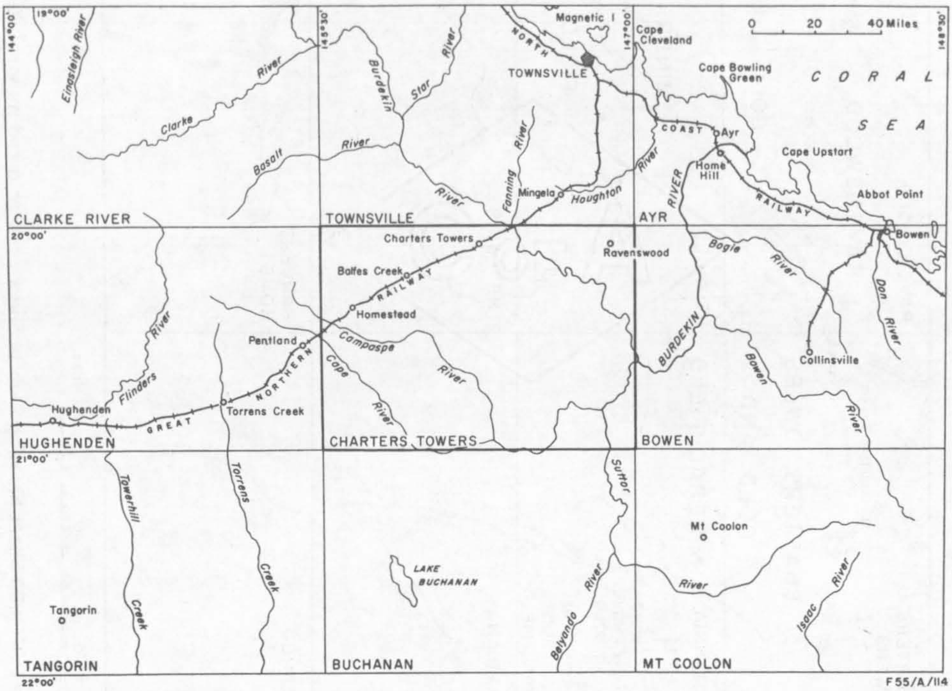

Fig. 1. Locality map and Sheet Index.

Charters Towers (population 8000), the only town in the area, is 80 miles by road southwest of the port of Townsville. It lies on the Flinders Highway and Great Northern Railway, which run side by side across the northwestern part of the Sheet area. Ravenswood, an old gold-mining centre but now a ghost town, is in the northeast corner and is connected by 25 miles of well formed gravel road with the Flinders Highway at Mingela in the Townsville Sheet area. Balfes Creek and Homestead are small settlements on the highway and railway in the west. The Gregory Developmental Road (largely gravel surface) runs south from Charters Towers across the centre of the area to Clermont, 240 miles south of Charters Towers. A system of shire roads and station tracks provides good access to most areas except the Robey and Leichhardt Ranges. A lack of bridges or safe fords across the Burdekin River necessitates indirect travel routes in the east. Rail services connect Charters Towers with Mount Isa, 500 miles to the west, and with Townsville. Charters Towers is a regular port of call for air services between Townsville, Mount Isa, and Darwin. Many of the cattle stations have landing strips suitable for light aircraft.

Beef cattle raising is the main industry of the area.

The topographic and planimetric maps covering the Sheet area are listed in Table 1 and the air-photographs in Table 2.

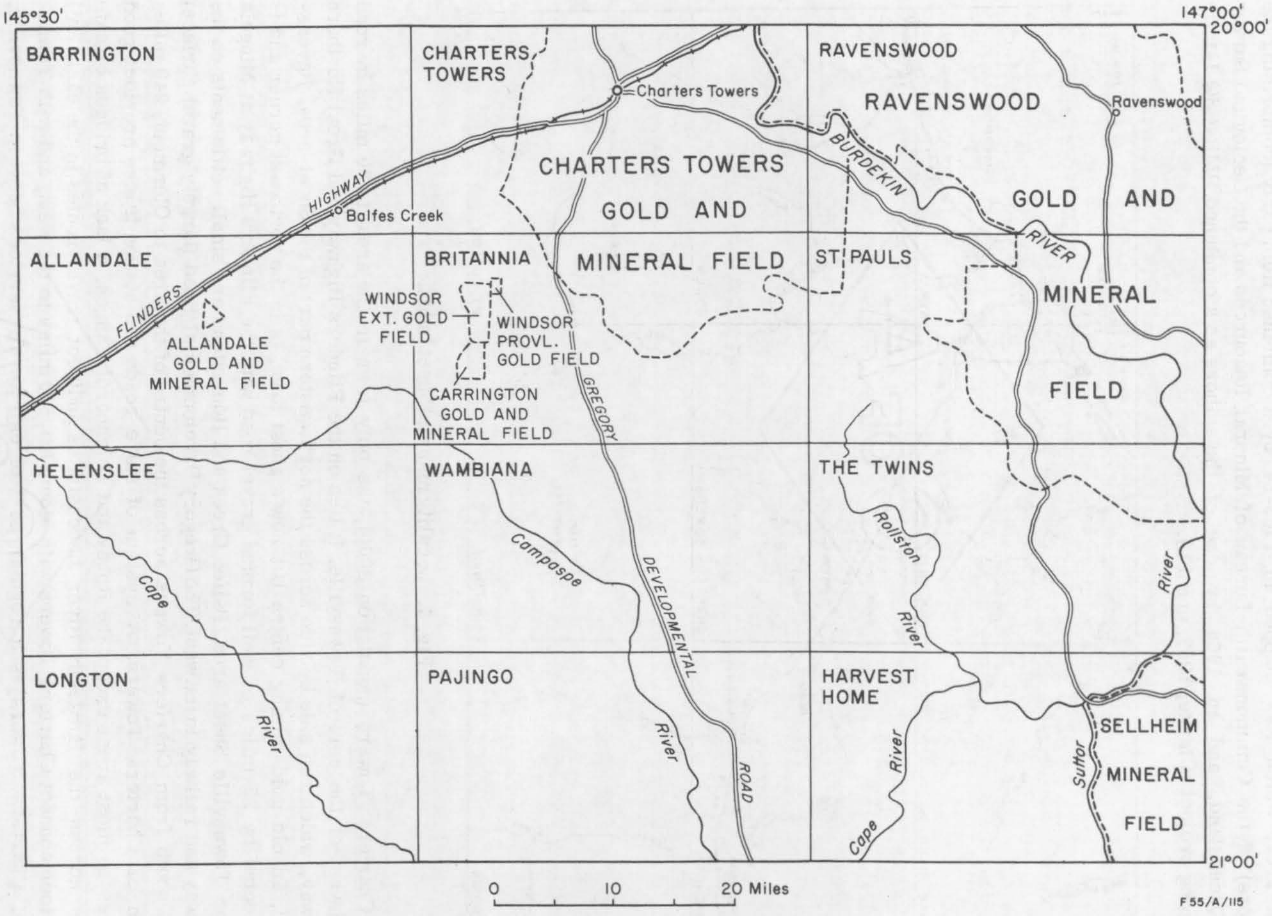

Fig. 2. Charters Towers 1:250,000 Sheet Showing 1-mile Sheets and gold and mineral fields.

TABLE 1 : TOPOGRAPHIC AND PLANIMETRIC MAPS

Type	Scale	Name of Sheet and Number	Produced By	Date
Planimetric Military Sheet	1:253,440 (4 miles to 1 inch)	Charters Towers SF55-2, No. 1214	Royal Aust. Survey Corps	1944
Topographic Military Sheet	1:250,000	Charters Towers SF55-2, Ed 1, Series R502	Royal Aust. Survey Corps	1964
Planimetric Military Sheet	1:63,360	Charters Towers No. 141	Royal Aust. Survey Corps	1942
Planimetric	1:253,440	Queensland 4-mile Series	Dept of Lands, Brisbane	
		4M-79		1963
		4M-80		1962
		4M-87		1958
		4M-88		1962
Planimetric	1:126,720	Queensland 2-mile Series	Dept of Lands, Brisbane	
		2M-346		1963
		2M-349		1964
Planimetric	1:31,680	Queensland Parish Maps	Dept of Lands, Brisbane	
		Black Jack		1962
		Charters Towers		1959
		Millchester		1962
		Sellheim		1964
		Southern Cross		1964
		Leyshon		1963
		Ravenswood		1950

TABLE 2 : AIR-PHOTOGRAPHS

Scale	Name and Area Covered	Flown By	Date
1:24,000	Burdekin Ponded Area	Adastra Airways Pty Ltd	1951
1:9600	A. to P. 140M, area No. 2	Adastra Airways Pty Ltd	1961
1:85,000	Charters Towers 1:250,000 Sheet	Adastra Airways Pty Ltd	1961
1:24,000	Britannia 1-mile Sheet	Adastra Airways Pty Ltd	1961
1:24,000	Charters Towers 1-mile Sheet	Adastra Airways Pty Ltd	1962
1:24,000	Ravenswood 1-mile Sheet	Adastra Airways Ptd Ltd	1962

Climate

The climate of the area is tropical. It is warm and dry in winter, and hot and wet in summer. Two-thirds of the annual rainfall falls from December to March; July to October is the driest period. Except for the Leichhardt Range in the northeast, where the annual rainfall varies from 25 to 30 inches, the area lies between the 20 and 25-inch isohyets. Rainfall decreases to the south and west. At Charters Towers the average daily minimum and maximum temperatures range from 51.6^{o}F and 76.0^{o}F in July, to 96.7^{o} in December. There are occasional light frosts. The Burdekin River, the main water-course in the area, is generally perennial, although in very dry seasons it may be reduced to a chain of waterholes. The smaller streams flow only after heavy rain.

Vegetation

Eucalypt woodland and savannah cover most of the Sheet area. Patches of brigalow occur south of the Seventy Mile Range, and mixed scrub about Barrabas Creek and Rishton. Heteropogon contortus (spear grass) is the dominant grass.

Previous and Contemporary Investigations

In 1847 Leichhardt followed the Suttor River downstream to its junction with a larger river, which he named the Burdekin; he followed the Burdekin River upstream, and then travelled through part of the Charters Towers Sheet area. Leichhardt named many of the prominent geographical features and made some geological observations (Leichhardt, 1847). The discovery of gold at Ravenswood in 1868 and at Charters Towers late in 1871 led to a series of geological investigations. Daintree (1870) briefly described the gold deposits at Ravenswood, and in 1879 Jack described the granite and metamorphic rocks at Charters Towers, the volcanic rocks of the Seventy Mile Range and Mount Leyshon, the Cainozoic sediments of Little Red Bluff, and those now called the Sellheim Formation. The volcanic rocks at Mount Leyshon and Mount Mawe were described more fully by Jack in 1885. In 1891 Rands made a reconnaissance traverse from Pentland to Mount Wyatt via Thalanga, Charters Towers, Mount Leyshon, Dreghorn, Harvest Home, and Mount McConnell. This survey gave a general outline of the geology in the northern and eastern parts of the area. In 1892 Jack, Rands, & Maitland produced a geological map of the Charters Towers goldfield on a scale of 4 chains to an inch. A second edition, on which the underground workings were plotted, was published in 1898. In 1892 Jack & Etheridge summarized the geology as then known.

Between 1880 and 1910 the rich gold lodes of the Charters Towers and Ravenswood goldfields were the subject of many investigations and publications; these were principally concerned with local features, and added little to the regional geological picture as established by Jack and Rands. However, Maclaren (1900) compiled a regional geological map of the northeastern part of the Sheet area, and a more detailed map and report on the mines about Ravenswood.

Marks (1912) published a short paper on the geomorphology of the Burdekin River downstream from Macrossan. In 1913 he reported on the 'outside' mines of the Charters Towers goldfield, and published a large-scale map covering the southern part of the field. The most comprehensive study of the goldfield in the environs of Charters Towers is by Reid (1917), and the detailed geological map at a scale of 8 chains to an inch, which he produced in 1918, incorporated the results of all previous mapping in and around the town.

Most of the numerous reports published by the Geological Survey of Queensland during the period 1920-67 were concerned with the inspection of relatively small mineral deposits. The geology of the Charters Towers town area was reviewed and re-interpreted by Connolly (1935, unpubl.) and Blatchford (1953). Levingston (1956) mapped the area between Liontown and the Gregory Developmental Road. A helicopter reconnaissance gravity survey of the northern parts of the Eromanga and Drummond Basins was completed by the Bureau of Mineral Resources in 1963 (Gibb, 1968).

An unpublished report on the 1963-64 regional mapping was produced by Wyatt et al. (1967). In 1966 the Ravenswood 1-mile Sheet area was mapped in detail, as a joint GSQ-BMR project (Clarke, 1969, unpubl.). In 1966-67 the southeastern corner of the Sheet area was re-examined by Olgers and others, as part of the regional mapping of the Drummond Basin (Olgers et al., 1967, unpubl.; Olgers, 1969, in prep.). In this Report, the interpretation of the distribution of rock units in the Drummond Basin is based upon information supplied by Olgers. This Report is a revised version of the unpublished 1967 report of Wyatt and others, and incorporates summaries of results since obtained by Clarke (1969, unpubl,) and by Olgers (1969, in prep.). The geology of the whole Sheet area is summarized by Clarke & Paine (1970). The 1:250,000 geological maps and explanatory notes for the adjoining Sheet areas have either been published or are in preparation: Townsville (Wyatt, 1968), Clarke River (White, 1962), Hughenden (Vine & Paine, in prep.), Tangorin (Casey, 1969), Buchanan (Olgers, 1969), Mount Coolon (Malone, 1969), Bowen (Paine, in prep.), and Ayr (Gregory, 1969). The area covered by J.H. Reid's detailed map of 1918 was not mapped in the course of this regional survey; a simplified version of Reid's map has been incorporated in the First Edition of the geological map of the Charters Towers 1:250,000 Sheet area (see Pl.).

A programme of isotopic dating of rocks from the region has been carried out at the Australian National University by A.W. Webb of the Bureau of Mineral Resources (see Webb, 1969). The K/Ar ages cited are accurate to within $\pm$ 3 percent, unless otherwise stated; the results are listed in Appendix 3.

The geological time-scale of Harland et al. (1964, pp. 260-2) is used in this Report.

Acknowledgments

R.R. Vine provided the data on the Warang Sandstone and Betts Creek Beds, which were mapped in 1964 as part of the regional survey of the Galilee and Eromanga Basins.

Miss B.R. Houston, of the Geological Survey of Queensland, has described numerous thin sections, and the results of her work have been incorporated in the text. The results of petrological work by W.R. Morgan and F. de Keyser have also been included.

PHYSIOGRAPHY
(Fig. 3)

Except in the extreme northeast corner, all the drainage in the Sheet area flows into the Burdekin River. The Seventy Mile Range in the central part of the area forms an important divide between the streams flowing north directly into the Burdekin River, and those flowing south to join its major tributaries, the Campaspe and Cape Rivers.

Most of the Sheet area lies between 750 and 1250 feet above sea level. The extremes of elevation are 400 feet near Hillsborough in the northeast, and 3040 feet in the Pentland Hills in the west. Relief is generally only moderate, but in some of the ranges it is as much as 1700 feet.

Hills and ranges of widely differing elevations occur throughout the Sheet area but mainly in the northwest and northeast. In the northwest the rugged Pentland Hills (granite) dominate the landscape, rising 1700 feet above the lower country on all sides except the north. In the northeast of the Sheet area the Robey Range (volcanics and granite) and the hills northeast of Ravenswood (granite) are quite rugged, with local relief up to 1000 feet.

The Seventy Mile Range, in the centre of the Sheet area, is composed mainly of the Mount Windsor Volcanics which form smooth hills rising 500 to 700 feet above the surrounding country. The Tuckers and Kirk Ranges in the northeast are uneven boulder-strewn hills and ridges of gabbro, granodiorite, adamellite, and granite, which rise above the undulating country of the Ravens9od Granodiorite Complex.

In the southeast the tightly folded arenites of the Drummond Group give rise to discontinuous north-northeasterly trending ridges which are steep but rarely more than a few hundred feet high.

Granite occupies much of the northeastern part of the Sheet area, and gives rise to dissected lower-lying country, which in places is rugged in miniature. Similar country is found near Homestead, where it is developed on schists of the Cape River Beds, and along the Suttor and Cape Rivers, where it has formed on the more easily eroded formations of the Drummond Group.

The northeastern part of the area is traversed by the Burdekin River, which was superimposed on the Ravenswood Granodiorite Complex after cutting through a cover of lateritized early Tertiary sediments, some of which remain in small mesas. Although the river flows generally southeast, its course is irregular. The irregularity does not appear to be related to any structural control in the granite bedrock, and it is assumed to be inherited from a meandering course in a broad shallow valley on a land surface which formed in the early Tertiary.

Extensive plains are developed on the Cainozoic Campaspe Beds and to a lesser degree on the Cainozoic basalts. Between the Cape and Campaspe Rivers the regional slope is to the southeast at less than 10 feet per mile, and the drainage is consequent. Locally the larger streams are incised 20 to 30 feet. In general the plains coincide with the ferricrete developed on the Campaspe Beds.

Gently undulating, sand-covered tablelands are formed on the laterite. One such tableland occurs west of Charters Towers, between Southern Cross Creek and the Just Range. Its eastern margin is a low broken scarp, but west of the hamlet of Balfes Creek its surface slopes gently down and merges into the broad plains bordering Balfes Creek.

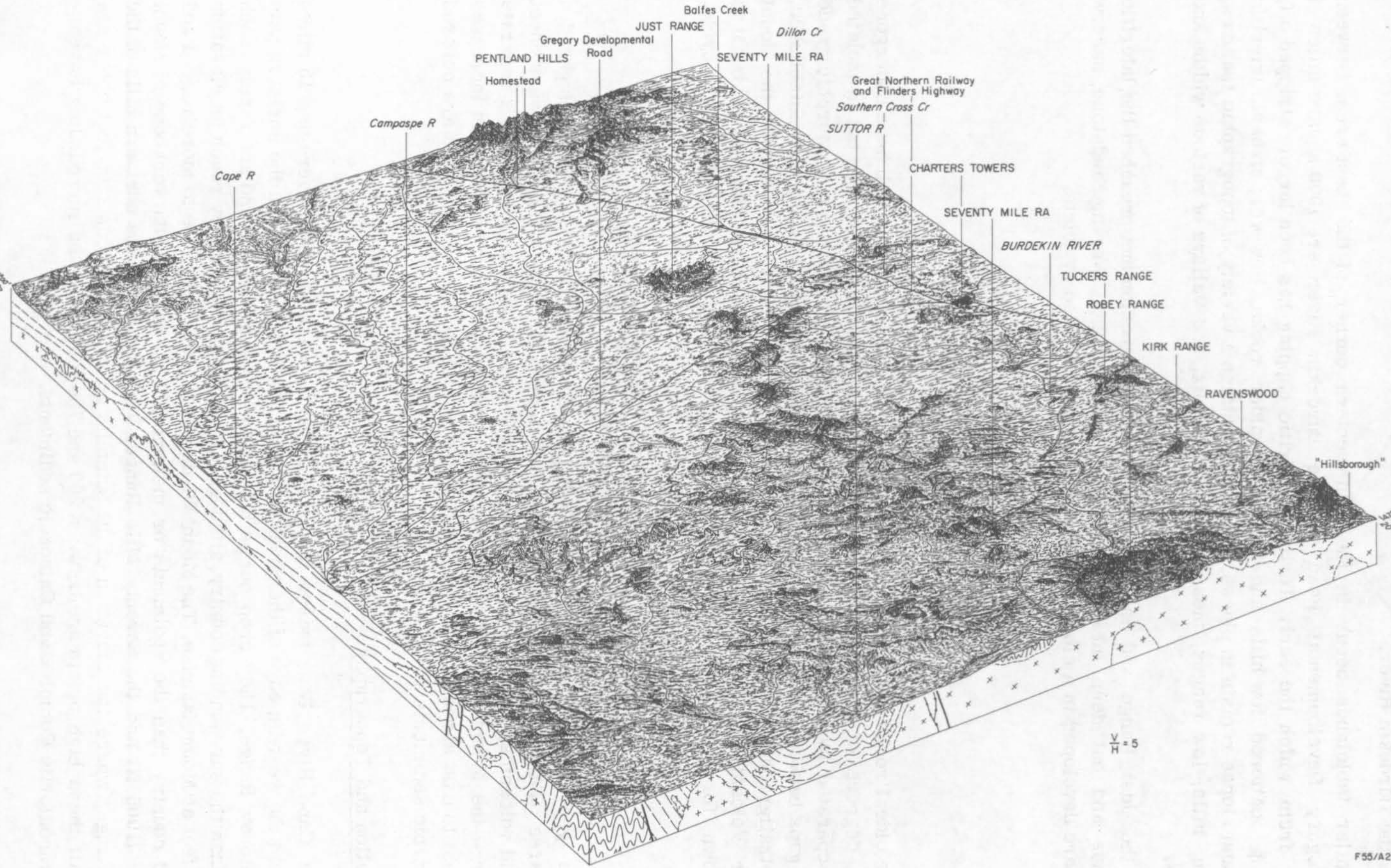

Fig. 3. Physiographic block diagram.

Another tableland occurs near the eastern margin of the Sheet area, but west of the Burdekin and Suttor Rivers; its surface is flat, but its northeastern end dips gently towards the Burdekin River.

Similar tablelands occur in the southwestern corner of the Sheet area. Between the Gregory Developmental Road and the Burdekin River are 1000 square miles of country from which the early Tertiary lateritic capping has been largely stripped off, revealing scattered low hills and ranges of older rocks. However, sizeable lateritic mesas and slopes remain in places. This area contains a variety of topographic features, including hills, low ranges, mesas, buttes, plateaux, and valleys of various widths and profiles.

In the Just Range and in the southwest, where erosion has breached the lateritic tablelands and cut deep into the underlying subhorizontal Warang Sandstone, narrow gorges are developed in a close rectilinear pattern controlled by joints.

CAMBRIAN-ORDOVICIAN
(Table 3)

The oldest rocks in the Sheet area are sediments and volcanics which have undergone varying degrees of thermal and dynamic metamorphism and now crop out in isolated areas separated by expanses of granite. Because of the variations in metamorphic grade and the gaps between outcrops the general stratigraphic sequence has not been established. Three stratigraphic units have been erected: the Cape River Beds (which include the Mount Windsor Volcanics), Charters Towers Metamorphics, and Kirk River Beds, but it is not known for certain whether they are the products of a single sedimentary cycle.

Cape River Beds and Mount Windsor Volcanics
(new names)

The type area of the Cape River Beds is in the Pentland district, in the Hughenden Sheet area (Paine et al., 1965, unpubl., and in prep. b). In the Charters Towers Sheet area acid volcanics, which do not occur in the type area, have been mapped as a separate member - the Mount Windsor Volcanics. The relative abundance of volcanics increases from west to east across the Sheet area. Large areas of the Cape River Beds are covered by Cainozoic sediments and laterite.

Distribution and Topography

The Cape River Beds extend in a discontinuous east-west belt averaging 15 miles wide from the western edge of the Sheet area near the Pentland Hills in the northern part of the Robey Range. They crop out as low hills with gentle slopes, and are rarely much higher than the surrounding country, although in the Rollston Range they reach an elevation of 1700 feet at Mount Sunrise. The Mount Windsor Volcanics give rise to more rugged and elevated country than the sediments or metamorphics, and form the backbone of Mount Windsor (1905 ft) and the Seventy Mile Range. They also form the northern hills of the Robey Range, where the elevation of the summits generally exceeds 1500 feet above sea level. All these high points are between 300 and 700 feet above the surrounding Ravenswood Granodiorite Complex and Cainozoic sediments.

Lithology of the Metasediments

In the Hughenden Sheet area the Cape River Beds are regionally metamorphosed, but the metamorphic grade diminishes eastwards. In the Mundic Creek/Homestead district the main rock type is sericite schist in the greenschist facies. Farther east the grade falls even more, so that east of longitude 146^{o} the sequence is not regionally metamorphosed. East of here metamorphism, where present, is a thermal feature related to the Ravenswood Granodiorite Complex, and is expressed by local shearing and strong hornfelsing.

The discontinuous outcrop areas of the Cape River Beds are described below in turn, starting in the west.

North of Homestead, in the headwaters of Deadman Creek, is an area of poorly exposed fine-grained brown mica schist and a few small outcrops of calc-silicate hornfels. The trend of the foliation ranges from southeast to east-southeast, and the dip from vertical to steeply southwest. Farther north, near the Deadman Fault Zone, cobbles of hematitic phyllite, hornfels, and actinolite schist have been observed in the creeks. Rands (1891) reported outcrops of schist in the granite in the headwaters of Homestead and Deadman Creeks. One of the calc-silicate hornfelses consists of about 40 percent quartzofeldspathic material, 40 percent porphyroblastic garnet, 20 percent clinopyroxene (probably diopside), and minor epidote. One of the cobbles of actinolite schist from the Deadman Fault Zone contains bands of material resembling recrystallized mylonite, and another consists of a groundmass of muscovite, biotite, quartz, and cordierite with porphyroblasts of staurolite or andalusite which have been completely altered to white mica and chlorite.

West of Homestead, northwest of the Flinders Highway, khaki hematite-sericite phyllite and schist predominate. Other rock types noted include banded blastoporphyritic hornfels, probably a metarhyolite, with up to 5 percent pyrite in thin stringers concordant with the banding; biotite-muscovite schist; strongly foliated medium-grained metadolerite or metabasalt of the greenschist facies; weakly foliated granofels, possibly derived from an acid volcanic rock or microgranite; and recrystallized fine lithic subgreywacke with clasts of quartzite and sericite schist. West of Homestead the foliation generally trends east-northeast and dips steeply to the south.

Farther southwest, in the Estland/Yarraman Park area, the main rock type is a banded fine-grained granofels, but hematitic phyllite and flaggy impure sericitic quartzite are also present. The granofels, which is composed essentially of quartz, feldspar, and biotite, was probably an acid volcanic rock. The trend of the foliation ranges from east to northeast, and the dip is south or southeast at 30^{o} to 75^{o}.

Southwest of Allan Hills homestead the low hills trending northwest represent strike ridges of quartz-mica phyllite and minor sheared fine-grained subgreywacke. In places the phyllite is dark grey, and possibly carbonaceous. Muscovite-biotite schist crops out sparsely among the phyllite in the low country north and south of the strike ridges.

Similar phyllites crop out in the low hills and rises north of the Campaspe River, west of Trafalgar homestead. Both here and southwest of Allan Hills homestead bedding can be recognized. The fine-grained sediments are thinly bedded, and in places the bedding coincides with a slaty cleavage. The trend ranges from west-northwest near Trafalgar homestead to northwest south of Allan Hills homestead. The regional dip is to the south at 25^{o} to 40^{o}, but northerly dips have also been recorded.

Southeast of Mount Trafalgar the sequence consists of indurated and in places slumped siltstone, dark grey mudstone, and minor quartzite, which dip southwest at about 45^{o}. The sediments are associated with rhyolite porphyry and andesite, but it is not known whether these form part of the sequence or are later intrusions. They have been mapped with the Mount Windsor Volcanics. The section exposed in this area is about 5000 feet thick.

:/70—2

TABLE 3. EARLY PALAEOZOIC STRATIGRAPHY AND IGNEOUS ACTIVITY

Age		Rock Unit (Reference)	Lithology	Remarks
U. SILURIAN OR L. DEVONIAN		Lolworth Igneous Complex S-D1 (1, 2, 4)	Banded, pegmatitic and aplitic garnetiferous muscovite granite and adamellite. Minor massive biotite adamellite	Intrudes C-Oc and Ravenswood Granodiorite Complex. Intruded by Mundic Igneous Complex. Gold, with minor lead, copper, and arsenic at Old Homestead diggings. Gold at Big Hit mine. Maybe source of mineralization at Lolworth diggings in Hughenden Sheet area.
U. SILURIAN OR L. DEVONIAN		Barrabas Adamellite S-Db (5)	Biotite adamellite and granodiorite; some biotite granite; later phase of leucoadamellite and micrograinite	Intrudes Ravenswood Granodiorite Complex. Copper-molydbenum mineralization at Keans prospect
M. ORDOVICIAN AND U. SILURIAN OR L. DEVONIAN	RAVENSWOOD GRANODIORTE COMPLEX	O-Da (3)	Pink and red biotite granite and adamellite, micrograinite, biotite pegmatite and aplite. Foliated in places	Unnamed scattered intrusions. Intrude C-O C-Oc, O-Dr. Minor gold mineralization near contacts
M. ORDOVICIAN AND U. SILURIAN OR L. DEVONIAN	RAVENSWOOD GRANODIORTE COMPLEX	Kirklea Granite (5)	Leucocratic biotite granite	Intrudes O-Dr. Lower contacts mostly gently dipping. Gold at Kirk
M. ORDOVICIAN AND U. SILURIAN OR L. DEVONIAN	RAVENSWOOD GRANODIORTE COMPLEX	Millaroo Granite O-Di (5)	Leucocratic biotite granite and adamellite; micrograinite	Intrudes C-Ow, C-Ok, O-Dr, and O-Dg. Cut by intrusion breccia (Cur) at Mt Wright. Numerous dykes. Contacts moderately to gently dipping. Gold mineralization at Ravenswood.
M. ORDOVICIAN AND U. SILURIAN OR L. DEVONIAN	RAVENSWOOD GRANODIORTE COMPLEX	Mosgardies Adamellite O-Dm	Porphyritic adamellite, granite, micrograinite	Intrudes O-Dr. Probably intrudes O-Dg but shearing obscures relationships. S contact dips gently to N. Micrograinite and microdiorite dykes. Minor gold mineralization
M. ORDOVICIAN AND U. SILURIAN OR L. DEVONIAN	RAVENSWOOD GRANODIORTE COMPLEX	Glenell Granodiorite O-Dg (5)	Porphyritic hornblende-biotite granodiorite	Intrudes O-Dr. Intruded by O-Di and probably by O-Dm. Minor associated gold mineralization

Age		Rock Unit (Reference)	Lithology	Remarks
M. ORDOVICIAN AND U. SILURIAN OR L. DEVONIAN	RAVENSWOOD GRANODIORITE COMPLEX	O-Do (6)	Olivine gabbro, leucogabbro; minor hornblendite, diorite, quartz monzonite	Irregular and dyke-like masses, in places with layering and orbicular structures. Largely overlain by black soil in some areas
		O-Dd (1, 4, 6, 7)	Quartz diorite and diorite	Small masses. Weather to largely black soil in some areas
		O-Dr (4-6, 8)	Hornblende-biotite granordiorite and tonalite. Minor adamellite, gabbro, and diorite SW of Burdekin R. Foliated in places	Initial most widespread phase of complex. Intrudes C-Oc and C-Of. Overlain nonconformably by upper M. Devonian sediments in Townsville Sheet area, and by Drummond Gp. Host to most of gold and other mineralization
CAMBRIAN TO ORDOVICIAN		Kirk River Beds C-Ok (3)	Micaceous shale, siltstone, feldspathic sandstone, greywacke	Poorly sorted; graded bedding and turbidity current structures. Intruded by O-Di. Unfossiliferous. Gold at Bunkers Hill in Townsville Sheet area
		Charters Towers Metamorphics C-Of (4, 6-10)	Mica schist, quartzite, quartz-feldspar-biotite schist, hornblende schist; cordierite, andalusite, and staurolite hornfelses; chlorite schist, marble	Minor gold deposits at Charters Towers. Thickness unknown
		Cape River Beds C-Oc (1, 2, 4, 11-13)	Schist, quartzite, phyllite, metavolcanics; siltstone, mudstone, arenite, pyritic shale; minor tuff; rare marble and calcsilicate hornfels	Dynamic and thermal metamorphism related to Ravenswood Granodiorite and Lolworth Igneous Complexes. In general, degree of metamorphism decreases away from contacts, from W to E, and from N to S. Unfossiliferous. Lead, silver, zinc, gold, and copper at Liontown. Small gold workings near Mt Leyshon, Dreghorn, Connolly Cr, and at New Homestead diggings
		Mount Windsor Volcanics C-Ow	Acid to intermediate volcanics, hornfels, schist, rare labile sediments	

Principal references: (1) Rands (1891); (2) Paine et al. (1965, unpubl.); (3) Wyatt et al. (1969, unpubl.); (4) This Report; (5) Clarke, (1969, unpubl.); (6) Reid (1917); (7) Maitland (1893); (8) Jack (1879); (9) Rands (1893); (10) Bryan (1926); (11) Jack (1885); (12) Maclaren (1900); (13) Levingston (1956).

In the Liontown area the sequence consists of thin-bedded phyllite, sheared arenite, and quartz-sericite schist. Fine-grained quartzite crops out 1 mile west of Liontown. The sediments are associated with acid volcanics, some of which are strongly sheared. There are also other fine-grained igneous rocks which are less sheared, and as they transgress the trend of the sediments they are assumed to be intrusive.

In the Windsor homestead area the Cape River Beds are severely jointed and fractured, and poorly exposed. The main rock types appear to be phyllite and grey impure quartzite. The trend of the foliation is irregular, but mainly east-west, and the regional dip is to the south. Weakly cleaved and sheared mudstone and arenite crop out in the low country south of Mount Windsor.

From Mount Leyshon southwards to the Seventy Mile Range, the rocks are similar to those near Windsor homestead. South of the range formed by the Mount Windsor Volcanics, in the headwaters of Little Policeman Creek, a sequence of interbedded sediments and volcanics grades up into a sequence composed entirely of sediments. The lower part consists of passage beds from the Mount Windsor Volcanics. The volcanics in the passage beds include rhyolite, dacite, acid tuff, and minor andesite. The rhyolite and dacite range from purple to creamy white. They are aphanitic and in places sparsely porphyritic. Some of them are flow-banded, others are massive. The tuffs range from coarse lapilli tuff to fine-grained varieties, and as they are interbedded with the sediments they were probably laid down under water.

The sediments associated with the volcanics range from thin-bedded mudstone to thick-bedded greywacke. In places the mudstone probably grades into tuff, and the greywacke appears to contain a high proportion of volcanic detritus.

Above the passage beds cream to light brown and green thin-bedded siltstone and mudstone predominate. They are generally siliceous and hard, and in places are cross-bedded. The beds of arkosic subgreywacke, which occur throughout the sequence, show graded bedding in places. Many of the sedimentary beds are strongly jointed, but not as intensely as the underlying Mount Windsor Volcanics. The dip of the sediments decreases to the south, where they are concealed by Cainozoic sediments. Assuming an average dip of 30°, a minimum thickness of 6000 feet is exposed.

Eight miles southeast of the Little Policeman Creek section, at the southwestern end of the Rollston Range, the alternating sequence of thin beds of siltstone and silty arenite has a conspicuous banded appearance. The sediments are generally reddish brown, and contain small scour structures. The Cape River Beds crop out in three inliers in the laterite 2 to 3 miles farther south and southeast. They consist mainly of pale mudstone and dark grey-green indurated arenite, which is micaceous in places. East of the inliers, near Six Mile Creek, and in the southern part of the Balaclava Range, the sediments are metamorphosed to fine-grained cream muscovite-biotite-qartz hornfels, spotted sericite hornfels, and minor hornfelsed calcareous siltstone containing tremolite.

In the Seventy Mile Range, about 10 miles west of Camp Oven Mountain, the Cape River Beds consist of subgreywacke, greywacke, feldspathic sandstone, indurated siliceous siltstone, quartzite, pyritic quartzite, arkose, shale, and mudstone. The sediments are generally well bedded, and the finer types are commonly very thinly bedded and are noticeably banded. Slump structures are common in the finer sediments, and graded bedding is common in the greywackes. Ripple marks (wavelength 1 cm) were seen in a fine-grained quartzite at one locality. The sequence here has been partly metamorphosed by the Ravenswood Granodiorite Complex and the variation in metamorphic grade suggests that the complex underlies the Cape River Beds at no great depth. For example south of Box Flat Dam, near the granite contact, there are outcrops of recrystallized feldspathic greywacke, subgreywacke, arkose, and spotted mica-quartz hornfels. Three miles north-northwest of the contact arkose, feldspathic lithic arenite, and sandy siltstone are apparently unaltered. Five miles north-northwest of the dam, however, and 2.5 miles from the nearest granodiorite outcrop, lithic greywacke and quartzite have granoblastic textures and contain abundant biotite in the matrix.

Fine-grained pink quartz-feldspar-muscovite-biotite schist and gneiss, biotite quartzite, and biotite gneiss form a roof pendant in the Ravenswood Granodiorite Complex 4 miles southeast of Cardigan homestead. They are intruded by numerous quartz and pegmatite veins. The pegmatites contain red-brown crystals of andalusite up to 1 inch long which are altered to aggregates of fine-grained mica.

Two miles northwest of Camp Oven Mountain, in a tributary of Dreghorn Creek, there are frequent outcrops of thinly laminated argillite and siltstone. Pyrite is abundant in the coarser-grained laminations. The pyritic beds are over 150 feet thick. For 2 miles south of the creek quartz-mica hornfels, calc-silicate hornfels, quartzite, and recrystallized subgreywacke crop out near the granodiorite contact.

In the headwaters of McDonald Creek, 10 miles west of Mount Cooper, the Cape River Beds form a range of hills rising about 400 feet above the surrounding country. They consist of thermally metamorphosed greywacke, subgreywacke, pebble conglomerate, and laminated siltstone. The clastic material in the coarser-grained rocks includes quartz, feldspar, micropegmatite, quartzite, and sericitized argillaceous rock fragments. Metamorphic biotite is strongly developed in the matrix of the sediments. Locally the greywacke includes fragments up to 2 feet long of thin-bedded and slumped siltstone. Graded bedding is characteristic of the subgreywacke, and very fine even bedding is characteristic of the siltstone. The sediments are highly fractured and are intruded by lamprophyre dykes.

The sequence of metamorphosed fine-grained labile arenite and siltstone at Mount Canton is tentatively assigned to the Cape River Beds. The arenite is grey-brown, and contains scattered large flakes of muscovite. The siltstone is dark grey to black, and carbonaceous. The rocks are strongly indurated and do not part readily along the bedding, which can be recognized only by the changes in lithology. Fragments of possible fossil plants were found in hornfelsed siltstone near the summit of the mountain. The hornfels consists of radiating rosettes of andalusite (average diameter, 0.5 mm), abundant sericite, carbonaceous material (probably graphite), black and brown iron oxides, and some quartz grains. The induration and metamorphism may have been caused by a dense swarm of red microgranite dykes which intrude the beds in the vicinity of Mount Canton, and which are probably related to a nearby late Palaeozoic granite stock. The age of the beds at Mount Canton and their relationship to the Ravenswood Granodiorite Complex is unknown. The presence of possible plant fossils in this isolated block of hornfels suggests that it may be an outlier of the Drummond Group.

Small roof pendants of feldspathic mica schist and corundum-cordierite-quartz-muscovite-biotite schist crop out in the Ravenswood Granodiorite Complex 2 miles south of Two Creek Dam. East of Mount Ravenswood homestead schist and quartzite crop out sporadically between ridges formed by east-northeast-trending dykes.

Northeast of Carse Creek, in the Robey Range, small isolated roof pendants of high-grade hornfels occur in granite of the unnamed late acid phase of the Ravenswood Granodiorite Complex (O-Da). Here the hornfels consists of quartz, muscovite, cordierite, chlorite, andalusite, and sillimanite. Much of the chlorite is derived from aggregates of altered stilpnomelane(?). The sillimanite occurs as rare needles associated with poikiloblasts of cordierite. The andalusite constitutes at least 10 percent of the rock, and occurs in aggregates of stumpy anhedra. A similar hornfels occurs in a very small roof pendant at the head of Carse Creek, where euhedral crystals of dark red garnet up to 1 inch in diameter and large crystals of andalusite up to 3 inches in length were noted.

Lithology of the Mount Windsor Volcanics

The type area of the Mount Windsor Volcanics extends from Mount Windsor to the western end of the Seventy Mile Range. The Mount Windsor Volcanics consist of rhyolite and dacite, with minor andesite, basalt, pyroclastics, and interbedded sediments. The proportion of sediments varies greatly.

At Mount Windsor, rhyolite is predominant. Flow banding can be distinguished in places, but the rock is generally even-textured and fine-grained. Fresh exposures are rare because the volcanics are closely jointed and fractured. Many of the rhyolites contain a few phenocrysts of quartz or feldspar (1-2.5 mm), and some are spherulitic. Scattered cubes of pyrite are common throughout the rhyolites. Some outcrops of greenish grey vesicular basalt(?), which is apparently interbedded with the rhyolite, occur just east of the Gregory Developmental Road. Most of the andesite occurs as dykes, but some flows are possibly present.

At Thalanga siding the low range of hills trending northwest is formed of strongly cleaved and hornfelsed acid volcanics. The hornfelses, which are very well exposed in a railway cutting made in 1963, are composed of biotite, sericite, quartz, and felsdpar, in varying proportions. The feldspar is usually oligoclase, but microperthite has also been noted. A little sheared agglomerate, volcanic breccia, quartz-mica phyllite, and biotite-muscovite-quartz schist are present. The phyllite and schist are probably metamorphosed tuffs or tuffaceous sediments. The textures range from granoblastic to lepidoblastic, and most of them are blastoporphyritic; the blastophenocrysts are generally quartz, in places bipyramidal, or chloritized biotite. All the rocks contain disseminated pyrite cubes. In places relict flow banding is visible. It is commonly crenulated and subhorizontal, its attitude therefore being almost normal to that of the near-vertical northwest cleavage, which is the dominant structure. The phenoclasts in the agglomerates and volcanic breccias have been elongated in the plane of the cleavage (Fig. 4). Veins of quartz-rich biotite pegmatite which intrude the volcanics have been boudinaged and attenuated where they trend parallel to the cleavage; where they transgress the cleavage they are isoclinally folded. Other pegmatites, which contain a bright red feldspar, show no stress effects and were presumably emplaced at a later stage.

The volcanics are cut by an altered microdiorite(?) dyke which has been converted to a schist composed of quartz, actinolite, biotite, clinozoisite, and feldspar; it was emplaced before the cleavage was developed.

Three miles north of Homestead metamorphosed siliceous rhyolite crops out north of a few low hills composed mainly of chloritic phyllite. The rhyolite is white to pale grey, and has a well developed foliation. In places the foliation planes are occupied by numerous small stringers of pyrite which form up to 10 percent of the rock. A similar rock nearby contains layers parallel to the foliation which are crowded with small octahedra of magnetite.

The volcanics are poorly exposed at several places in the Seventy Mile Range east of the type area. There are few fresh outcrops, and a thin cover of lateritic material commonly masks the underlying rocks. North of Rollston Hut the Mount Windsor Volcanics consist of rhyolite, andesite, rhyolite and andesite breccia, basalt, dolerite, and interbedded quartzite and minor pebble conglomerate and greywacke. The sequence is thermally metamorphosed throughout, and locally silicified and brecciated. The metamorphism has produced light grey spotted quartz-mica hornfels from some of the more quartzose sediments. The interbedded quartzite is very fine-grained and well laminated, but not fissile. The laminae average a quarter of an inch in thickness.

In the Dreghorn area the Mount Windsor Volcanics consist of andesite, basalt (commonly amygdaloidal), rhyolite, and doleritic volcanics with rare thin interbeds of grey quartzite.

The southern margin of the sequence is faulted against the Cape River Beds, and to the north and east it is intruded by the Ravenswood Granodiorite complex. The volcanics are strongly hornfelsed, and contain garnet, epidote, hornblende, diopside, and magnetite. The amygdales in the basalt consist of cores of amphibole rimmed with plagioclase and diopside. Breccia, schistose rocks, and mylonite occur at the intrusive contact; the contact rocks include schistose cordierite-feldspar-amphibole hornfels, quartz-mica hornfels, and quartz-mica-sericite hornfels. Andesite, blue-grey dolerite, and spessartite lamprophyre crop out to the south of the Heilanman mine. The dolerite and lamprophyre are no doubt later intrusions.

Fig.4. Magnesite vein cutting metamorphosed coarse lapilli tuff of the Mount Windsor Volcanics, N face of railway cutting, 1 mile NE of Thalanga siding. Slaty cleavage is crudely developed in the tuff, and the lapilli are strongly attenuated in the plane of the cleavage.

Southeast of Ravenswood the Mount Windsor Volcanics form the northern foothills of the Robey Range. They consist almost entirely of acid lavas, the most typical being brownish green spherulitic rhyolite. A few dark grey lavas, possibly dacite, are also present. Dacite is predominant in Fish Creek, 3 miles east of Connolly homestead. It consists of phenocrysts of oligoclase (30%) and quartz (5%) set in a groundmass of feldspar (35%), quartz (20%), and chlorite (10%). Altered basalt, andesitic agglomerate, and minor micaceous shale were also recorded in this area. The sequence is intruded by dykes of microdiorite and spessartite lamprophyre.

Maclaren (1900) described greywacke, silty shale, altered sandstone and micaceous sandstone 'in the neighbourhood of Tucker and Fish Creeks'. Traverses in Fish Creek failed to locate these rock types in situ, but loose pieces of recrystallized medium-grained subgreywacke occur in the bed of the creek. The subgreywacke contains subangular to subrounded clasts of fine quartzite.

Thickness

The thickness of the Cape River Beds is unknown because of the discontinutiry of outcrop and lack of structural information. At least 5000 feet of section is exposed near Mount Trafalgar and at least 6000 feet occurs south of the Seventy Mile Range, north of Bletchington Park homestead, but the total thickness is probably considerably greater.

The intense jointing in the Mount Windsor Volcanics makes it difficult to recognize the attitude of the bedding or flow banding. The flow banding is generally contorted and seldom dips at less than 45^{o}. If it is assumed that the Mount Windsor Volcanics north of Rollston Hut have a regional southerly dip similar to the enclosing sediments of the Cape River Beds, then they have a thickness of 10,000 to 15,000 feet. The Mount Windsor Volcanics probably consist of a number of separate volcanic sequences which thin out away from each volcanic centre. A regional thinning to the west is also apparent, and the volcanics are absent in the Hughenden Sheet area.

Metamorphism

In the Charters Towers Sheet area the metamorphism of the Cape River Beds is thought to be broadly related to the intrusion of the Ravenswood Granodiorite Complex. Deformed pegmatites occur in metamorphics in the railway cutting at Thalanga. The metamorphism has not been sufficiently high in grade to generate pegmatites spontaneously, and the veins must therefore be related to granite. This shows that this area at least was subjected to stress after an episode of granite emplacement.

In the central and eastern parts of the Sheet area schistose or foliated rocks are not generally found more than 2 to 3 miles from the granodiorite contact, and north of Brittania homestead, the foliation dies out and gives way to strong jointing to the south. In places the foliation may have been produced by the intrusive force of the granodiorite which is itself commonly foliated. The outcrop of the intrusive contact is irregular, and its relationship to the topography suggests that the contact dips at a low angle below the Cape River Beds.

In the Hughenden Sheet area the Cape River Beds consist of schist, gneiss, and quartzite in the greenschist and almandine-amphibolite facies of regional metamorphism (Turner & Verhoogen, 1960), and a Rb/Sr isochron of 486 ± 20 m.y. (Lower Ordovician) was obtained from them. This suggests a regional metamorphic event in the Hughenden Sheet area which is distinctly older than the Ravenswood Granodiorite Complex. The effects of this metamorphism may have extended into the western part of the Charters Towers Sheet area.

Mineralization

Most of the mineralization in the Cape River Beds occurs near the contact with the Ravenswood Granodiorite Compled, and is presumed to be related to the complex. For example, the silver-lead deposits at Liontown are probably related to porphyries which are interpreted as apophyses of the late granite phase of the complex (P-Da). However, the gold mineralization at the Old Homestead diggings 7 to 8 miles north of Homestead is probably related to the Lolworth Igneous Complex. Here much of the gold occurs in lodes at the contact between the granite and small roof pendants of schist.

Stibnite occurs in a sheared and altered volcanic(?) rock at The Antler mine, 3 miles west-northwest of Homestead. The nearest exposed granite, which has been mapped tentatively with the late acid phase of the Ravenswood Granodiorite Comples, lies 1 mile to the south.

Several minor mineral occurrences were recorded during the regional mapping. The pyrite and magnetite north of Homestead have already been noted. Veins of magnesite up to 2 inches thick, and a sphalerite vein one-eighth of an inch thick occur in volcanics in the railway cutting east of Thalanga siding. The sphalerite vein was observed in a block broken during excavation of the cutting. Pyrite and occasional chalcopyrite occur as sparse disseminations in this area. Pebbles of barite were found in a creek bed at the southeastern end of the range which extends southeast from Thalanga siding.

Environment of Deposition

The poor sorting and presence of graded bedding in many of the arenites suggest a low-energy environment of deposition. This is also indicated by the abundance of laminations in many of the finer-grained sediments. It is possible to suggest, from this, that the Cape River Beds were laid down in a eugeosyncline. However, the greywackes, subgreywackes, and arkoses may in fact represent the erosional products of the contemporaneous Mount Windsor Volcanics, and their composition and poor degree of sorting could be a reflection of provenance rather than a true indication of depositional environment.

Age

Apart from the possible plants at Mount Canton, no fossils have been found in the Cape River Beds.

The Cape River Beds are intruded by the Ravenswood Granodiorite Complex. Middle Ordovician and Upper Silurian/Lower Devonian isotopic ages have been obtained from parts of this complex, but no specimens from near the contact have been dated. Therefore it is not possible to be sure on these grounds alone that the Cape River Beds are older than the Middle Ordovician intrusions. A preliminary Rb/Sr whole rock isochron of 510 ± 100 m.y. (Upper Cambrian) has been obtained from the Mount Windsor Volcanics in the Leichhardt Range in the Bowen Sheet area. In view of this and of the metamorphic age obtained in the Hughenden Sheet area, the Cape River Beds are regarded broadly as Cambrian to Ordovician in age. The isochron obtained from the Licehhardt Range represents the first dated occurrence of outcropping Cambrian rocks in the Tasman Geosynclinal Zone in Queensland.

Charters Towers Metamorphics

Several roof pendants of metamorphic rocks are present in the Ravenswood Granodiorite Complex near Charters Towers. The largest lies immediately northwest of Charters Towers, and scattered small outcrops extend north of the town into the Townsville Sheet area. The most southerly occurrence was recorded in diamond drill cores at the Mabel Jane East mine, in the east bank of Rocky Creek, 8 miles south of the town (Tucker, 1962, unpubl.)

The metamorphics at Charters Towers have been described by Jack (1879), Maitland (1893), and Reid (1917). Bryan (1926) named them the Charters Towers Series, but in accordance with the Australian Code of Stratigraphic Nomenclature, the name has been revised to Charters Towers Metamorphics (Wyatt, 1968).

The largest roof pendant consists chiefly of mica schist and quartzite. Similar rocks also crop out east of Merry Monarch Creek. Chlorite schist forms the northern foot of Lincoln Hill, and is reported to occur near the racecourse (Reid, 1917). Staurolite hornfels crops out in Charters Towers. Quartz-feldspar-biotite schist, hornblende schist, and anthophyllite-andesine-quartz schist were recorded from the drill hole at the Mabel Jane East mine; Tucker (1962, unpubl.) considers that some of the metamorphics were derived from basic volcanics.

The foliation in the Charters Towers Metamorphics trends northwest, and dips vertically or steeply to the northeast. Reid (1917) estimated a thickness of 7000 feet for part of the sequence, but considered that the total thickness may be considerably greater.

Bryan (1926) suggested a late Precambrian age for the metamorphics. However, there seems no reason to regard the Charters Towers Metamorphics as older than the Cape River Beds, for which a Cambro-Ordovician age is indicated. Although the Charters Towers Metamorphics are generally more schistose than the Cape River Beds in the Charters Towers Sheet area, the difference is probably due to shearing and granite emplacement, and does not necessarily denote a significant difference in age.

Kirk River Beds

The Kirk River Beds (Wyatt et al., 1969) extend south from the Townsville Sheet area, and cover about 3 square miles of the Charters Towers Sheet area immediately west of Blue Mountain. They form low hills with a fairly close drainage pattern.

The Kirk River Beds were only briefly examined in the Charters Towers Sheet area, and for further information the reader is referred to Wyatt et al. (1969). In the Charters Towers Sheet area they consist of micaceous shale, siltstone, feldspathic sandstone, and greywacke. The sediments are poorly sorted, and graded bedding and turbidity structures are characteristic.

No fossils have been recorded in the Kirk River Beds. The beds are intruded by the Ravenswood Granodiorite Complex, and are regarded as the same age as the Cape River Beds.

Gold occurs in the Kirk River Beds at Bunkers Hill in the Townsville Sheet area.

MIDDLE ORDOVICIAN AND UPPER SILURIAN OR LOWER DEVONIAN
(Table 3)

Ravenswood Granodiorite Complex

Background and Discussion of Age

A large batholith consisting mainly of granodiorite occupies 2000 square miles in the Charters Towers Sheet area and a further 1000 square miles in adjoining Sheet areas. In addition several hundred square miles of Cainozoic sediments and laterite west of Charters Towers are probably underlain by the batholith.

The batholith was defined and named Ravenswood Granodiorite by Wyatt et al. (1969) and the name was first published by Wyatt in 1968. Wyatt et al. recognized a broad twofold subdivision, an initial granodiorite phase and a later granite (or acid) phase. At that stage the only isotopic dates available were three K/Ar mineral ages of 420, 420, and 440 m.y. (Lower Silurian), which had been obtained from two specimens of granodiorite in the Townsville Sheet area. A general Silurian-Devonian age was proposed, for the acid phase had not been dated, and K/Ar mineral ages at or near the Silurian-Devonian boundary had been obtained from other granites in the region. This age was also published on the Townsville 1:250,000 geological map because the explanatory notes went to press before any further results became available.

In 1966, during the course of 1-mile mapping of the Ravenswood Sheet area, Clarke (1969, unpubl.) recognized 8 distinct subunits of the batholith, and it was decided to revise the name to Ravenswood Granodiorite Complex.

In 1967/68 specimens collected by Clarke, together with others collected from both 1:250,000 Sheet areas during the earlier regional mapping, were dated by the Rb/Sr whole-rock method (Webb, 1969), which, in this region of repeated granite intrusion, has proved more reliable than the K/Ar method as an indicator of absolute age (Webb & McDougall, 1968; Webb, 1969). Two distinct isochrons were obtained, at 454 $\pm$ 30 m.y. (Middle Ordovician) and 394 $\pm$ 30 m.y. (Upper Silurian or Lower Devonian). No intermediate ages were determined. Specimens collected from both the granodiorites and the acid rocks lie on both isochrons, thereby proving that the interim twofold subdividion of Wyatt et al. (1969) and Wyatt (1968), which had been derived only from field work, was unsatisfactory. It now seems probable that each of the 2 intrusive epochs consisted of a granodioritic phase (or phases), followed by later more acid phases. There are no simple field criteria for distinguishing between the products of the two intrusive episodes. More detailed mapping and further isotopic dating will be required to identify them. The problem might be solved geochemically by trace element analyses; Webb (1969) has already noted a marked difference in the initial $^{87}Sr/^{86}Sr$ ratios of rocks from the two episodes.

Present knowledge suggests that the Ravenswood Granodiorite Complex is mainly Middle Ordovician, but contains unmapped masses which were emplaced in the uppermost Silurian or lowermost Devonian, for example at Ravenswood (GA5799), Sandy Creek (GA5706), and beside the Broughton River southwest of Charters Towers (GA5735). The Barrabas Adamellite, which was formerly included in the Ravenswood Granodiorite, is now distinguished and mapped as a separate unit which is clearly of Upper Silurian/ Lower Devonian age. It is felt that ideally the Ravenswood Granodiorite Complex should be mapped and defined so that it includes only Middle Ordovician intrusions, representing the products of a single major intrusive event. However, this is not practicable without further extensive and detailed mapping. We recommend that a policy of progressive removal of Upper Silurian/Lower Devonian plutons from the Ravenswood Granodiorite Complex, whenever they can be delineated (as has been done already with the Barrabas Adamellite), be followed by future workers in the area.

Details of the relationships of the Ravenswood Granodiorite Complex at Charters Towers and Ravenswood are discussed by Reid (1917) and Clarke (1969, unpubl.) respectively. The earliest and most widespread phase of the batholith consists mainly of granodiorite and is referred to as the 'main granodiorite phase' (O-Dr). Clarke distinguished a slightly later granodiorite phase, the Glenell Granodiorite. In the Ravenswood Sheet area several subunits of granite and adamellite which are later than the granodiorites have been named by Clarke Mosgardies Adamellite, Kirklea Granite, and Millaroo Granite. The Glenell Granodiorite, Mosgardies Adamellite, Kirklea Granite, and Millaroo Granite have all yielded the 454 m.y. isotopic age. There are many bodies of granite and adamellite in the Charters Towers Sheet area which have not been named, and are referred to informally as the 'late acid phase'. These have a tendency to occur around the margins of the batholith. Diorite (O-Dd) and gabbro (O-Do) are widely distributed but represent only a very small percentage of the complex. The evidence suggests that the diorite and gabbro intrude the main granodiorite phase, but their younger age limits are unknown.

All rock types of the Ravenswood Granodiorite Complex are strongly foliated in places, the granodiorites somewhat more so than the leucocratic rocks.

Parts of the Ravenswood Granodiorite Complex in the vicinity of Charters Towers, Sellheim, The Bluff, and Mount Windsor have been described by Jack (1879, 1885), Rands (1891), and Reid (1917). Maclaren (1900) described the granodiorite between Ravenswood and St Pauls homestead.

The granodiorites give rise to undulating country of low relief, with a fairly close dendritic drainage pattern. The more leucocratic rocks form hills which rise above the granodiorite, in places with considerable local relief. Diorite and gabbro usually give rise to flat country with dark soil and poor or no outcrop.

The subunits of the Ravenswood Granodiorite Complex are discussed below. The subunits which occur wholly within the Ravenswood 1-mile Sheet area (the Glenell Granodiorite, Mosgardies Adamellite, Kirklea Granite, and Millaroo Granite) are described fully by Clarke (1969, unpubl.), and are only summarized in this Report. The new units named by Clarke are formally defined in Appendix 3.

Main Granodiorite Phase (O-Dr)

The main granodiorite phase constitutes about 80 percent of the complex, and consists of granodiorite and minor tonalite. Wherever relationships have been determined the granodiorite is always older than the leucocratic subunits, and the main granodiorite phase is mapped as the oldest subunit, although the isotopic dating has shown that some parts are much younger than some of the leucocratic subunits.

The granodiorite is normally medium-grained, with a colour index of about 25 to 30. It may contain hornblende or biotite either alone, or together; the hornblende-bearing varieties in places grade into quartz diorite (Maitland, 1893; Reid, 1917, p. 199). Tonalites have been recorded in the Ravenswood/Sandy Creek district and beside the road 1.5 miles northeast of Two Creek hut (Fig. 5).

Cataclastic foliation, caused by post-crystallization shearing, is widespread in the main granodiorite phase.

Between Cardigan homestead and Camp Oven Mountain there are a number of east-northeasterly ridges, about 10 feet high, in the hornblende granodiorite. They consist of silver-green micaceous rocks composed of coarse platy green chlorite, quartz, and muscovite, and probably represent zones of intense hydrothermal alteration in which hornblende has been altered to chlorite and feldspar to muscovite.

The main granodiorite phase is the host for almost all of the gold mineralization in the Sheet area (Reid, 1917; Clarke, 1969, unpubl.). The tonalite which contains the gold lodes at Ravenswood has yielded the Upper Silurian/Lower Devonian age, suggesting that the gold mineralization, at least that at Ravenswood, is Upper Silurian/Lower Devonian or younger. A Lower Carboniferous K/Ar age (330 m.y.) has been obtained from dykes similar to those which cut the gold lodes at Charters Towers, and sets a younger limit on the age of the gold mineralization (Webb, 1969).

Diorite (O-Dd)

Diorite has been mapped near Charters Towers by Maitland (1893), Rands (1891), and Reid (1917). From mine and surface mapping Reid distinguished two period of diorite intrusion, separated by the intrusion of aplitic granite, all of which he considered to be younger than the main granodiorite phase. The small mass near Seventy Mile Mount consists of quartz diorite.

Gabbro (O-Do)

Reid (1917) mapped several small areas of gabbro in the vicinity of Charters Towers. He concluded that they were intruded after the granodiorite but before the younger of the two diorite phases. The large gabbro mass 7 miles southwest of Charters Towers is poorly exposed, but it appears to be intruded by aplite and pegmatite dykes.

Fig. 5. Garnet-biotite pegmatite intruding fine-grained melanocratic xenoliths in tonalite of the Ravenswood Granodiorite Complex. In creek bed immediately S of road to Burdekin Falls, 2 miles S of Lulu Pocket.

Jack (1886), on his map of Queensland, shows occurrences of basalt and the other basic igneous rocks including diorite at Black Knob beside the Gregory Developmental Road and in a smaller exposure to the west, but on his map of 1892 (Jack & Etheridge, 1892) he records them simply as volcanic foci. These occurrences, together with those shown on Reid's map, appear to be the only basic rocks recorded in the complex.

The basic rocks at Black Knob consist of gabbro, troctolite, and similar rocks rich in amphibole. They are commonly dark grey-green, but range from pale grey to black. At the southern end of the outcrop the basic rocks are very coarse-grained, and consist essentially of plagioclase, olivine, hornblende, and spinel. Some are orbicular. In the middle of the outcrop the rocks are finer and banded in places; they consist essentially of plagioclase, pyroxene, hornblende, and iron oxides. The banding, which is due to differences in grainsize, texture, or mineralogy, ranges from a few millimetres to more than 10 metres thick. In places the thinly layered rocks are highly disturbed, and the disoriented blocks have been intruded by coarser-grained basic material. At the north end a relatively homogeneous plagioclase-hornblende rock crops out. The broad subdivision into roughly east-west zones may represent large-scale layering in a basic mass.

Some of the predominantly coarse-grained rocks in the southern part of the Black Knob area range from porphyritic to even-grained or orbicular in texture. The porphyritic varieties consist of bytownite phenocrysts set in a slightly finer-grained matrix of hornblende, olivine, and alteration products of the same minerals. Some of the even-grained varieties consist of plagioclase, olivine, hornblende, pyroxene, spinel, epidote, margarite(?), chlorite, calcite, quartz, and a little magnetite and sulphides. Others contain a different amphibole (Fig. 6). The orbicular varieties contain plagioclase, olivine, hornblende, and some spinel in the orbicules, and plagioclase, hornblende, and alteration products in the coarse-grained pegmatitic material between the orbicules.

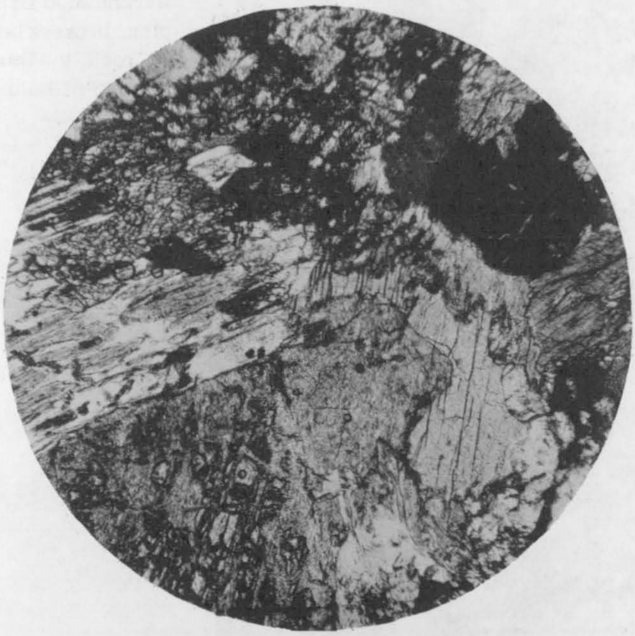

Fig. 6. Spinel-amphibole-olivine gabbro (Ravenswood Granodiorite Complex), Black Knob, 12 miles SSW of Charters Towers Crossed nicols, X45. Spinel occurs in the NW quadrant next to amphibole (tremolite, pargasite, or tschermakite). In the SE quadrant altered olivine (right) is adjacent to margarite, which, on the left, is altered to the light brown micaceous mineral dudleyite. The dudleyite is represented by darker patches in the elongated light-coloured grain.

The layered rocks in the central part of the Black Knob occurrence contain olivine, orthopyroxene, clinopyroxene, hornblende, biotite, iron oxides, iron and copper(?) sulphides, plagioclase, apatite, and quartz in varying proportions; clinopyroxene, hornblende, and plagioclase are the main constituents. They have a wide range in texture, and bands with ophitic, porphyritic, or granular textures are present within a few metres of each other.

To the north of the layered rocks the basic rocks are medium-grained and relatively homogeneous; they consist of plagioclase, hornblende, and iron oxides with a hypidiomorphic granular texture.

The basic rocks at Black Knob are in contact with and presumably intrusive into the Cape River Beds, but their relationship with the main granodiorite phase is not known.

In the olivine gabbro 7 miles southwest of Charters Towers the most notable feature is the conspicuous development of orbicules averaging about 6 cm in length and 1 to 5 cm in width. The gabbro is crudely banded in places; the banding is due to alternations of medium and coarse-grained material, or to the presence or absence of orbicules which are generally flattened parallel to the banding. The olivine gabbro in places grades into a leucogabbro free of olivine. The orbicules consist of a central core of ophitic pyroxene, enclosing anhedral olivine and subhedral plagioclase, surrounded by layers composed of granular olivine or an aggregate of olivine and plagioclase in which the plagioclase crystals are commonly radially aligned. The matrix between the orbicules is also composed of plagioclase, pyroxene, and olivine, but is generally coarser in grain. The composition of the orbicules is bytownite (40%), olivine (35%), augite (20%), hypersthene (5%), and minor opaque minerals. The matrix is composed of labradorite (45%), augite (35%), olivine altered to serpentine (10%), hypersthene (5%), hastingsite(?) (5%), and minor biotite and iron oxides. The quartz monzonite at the eastern end of the gabbro has been mapped with the gabbro. Its extent and relationship to the gabbro are unknown, as outcrops are sporadic and both rocks give rise to similar dark soils.

The other basic rocks west of the Burdekin River have been mapped mainly by the derived soils, although there are generally some sporadic outcrops. They range from gabbro to diorite, and in places are layered.

The gabbros and diorites northeast of the Burdekin River are described by Clarke (1969, unpubl.).

A swarm of gabbro dykes 2 miles wide cuts the main granodiorite phase a few miles north of the Valley Hut, near the Seventy Mile Range. A similar swarm crops out southeast of Mount Ravenswood homestead, where the dykes intrude both the granodiorite and the Cape River Beds.

Late Acid Phase (O-Da)

Bodies of granite and adamellite, which represent a late acid phase of the batholith, are widely distributed throughout the main granodiorite phase. However the greatest concentration is near the contact of the granodiorite with the Cape River Beds, which suggests that the late acid phase was emplaced at the margins of the batholith. The rocks of this phase range from medium-grained granite and adamellite to fairly coarse pegmatite, and from microgranite to aplite and fine-grained aphanitic porphyry. The coarser types generally occur near the granodiorite and the finer-grained varieties at the contact with the Cape River Beds or within the Beds themselves; some of the porphyries intruding the Cape River Beds near Liontown are probably apophyses from these acid intrusions. In most cases the younger age limit of these bodies is unknown, and it is possible that some may be late Palaeozoic in age. Clarke (1969, unpubl.) mapped five separate acid subunits of the complex in the Ravenswood area. The three which he named (Mosgardies Adamellite, Kirklea Granite, and Millaroo Granite) are shown on the map which accompanies this Report, and their characteristics are summarized below.

Various granites and adamellites crop out in the Robey Range. They are intruded by late Palaeozoic stocks and are thought to be nonconformably overlain by Upper Carboniferous(?) volcanics. The granites are resistant to erosion and form high hills in marked contrast to the low undulating country occupied by the granodiorite. The topography is controlled mainly by faults and joints, and to a lesser extent by variations in rock type. The northeastern end of the Robey Range is composed mainly of coarse red leucocratic granite, but to the south, surrounding Lulu Pocket, the main rock is a buff fine to medium-grained aplitic granite containing scattered clots of biotite and poikiloblastic plagioclase, while in the southwest, around Stony Creek and Two Creek, it is a very leucocratic aplitic granite containing muscovite in places. The inter-relationships of these older granites in the Robey Range are unknown.

Pink biotite granite, some strongly porphyritic, crops out immediately southeast of Camp Oven Mountain. It is much fractured and brecciated, and in places it is mylonitized (e.g. along St Pauls Creek). The breccias consist of angular fragments of granite, ranging from less than 1 cm to 25 cm across, set in a matrix of granulated granite, or rarely, of unbrecciated aplite. The granite is intruded by dykes of porphyritic andesite and intrusion breccia. It is nonconformably overlain by an outlier of the Scartwater Formation (Upper Devonian or Lower Carboniferous).

Pink porphyritic microgranite crops out 5 miles south of Mount Cooper. It consists of rounded phenocrysts of clear quartz up to 4 mm in diameter and large feldspar phenocrysts set in a fine graphic groundmass. A little biotite is the only mafic mineral present. The rugged hills of coarse biotite granite and microgranite 1 mile east of Mount Cooper are apparently part of the same mass.

Northwest of the junction of the Burdekin and Suttor Rivers is an area of granitic rocks composed of leucocratic granite, biotite alkali microgranite, and porphyritic microgranite, intruded by numerous grey-green quartz porphyry and flow-banded rhyolite dykes. Pebbles of this granite occur in sediments mapped with an Upper Devonian or Lower Carboniferous volcanic unit (D/Cv) a few miles to the south.

Leucocratic granites also crop out near the Valley Hut, south-southwest of Cardigan homestead.

The granite immediately north of Mount Leyshon is fine to medium-grained and leucocratic, but in places it grades into aplite or porphyritic microgranite. Farther west, south, and south-southwest of Black Knob, porphyritic microgranite predominates, and still farther west, near Windsor homestead, medium-grained granite crops out. In this area, the north-northeasterly trend visible on the air-photographs can be related to low poorly defined parallel ridges of granite separated by low-lying areas covered by red-brown clayey soil which is similar to that developed on parts of the granodiorite or dolerite dykes.

Foliated medium-grained pink biotite granite which forms a small hill surrounded by Cainozoic deposits 4 miles southwest of Balfes Creek, and coarse red biotite granite north of Thalanga homestead which is intruded by gently dipping sheets of pegmatitic muscovite granite of the Lolworth Igneous Complex, have both been assigned to the late acid phase of the Ravenswood Granodiorite Complex.

Six miles north of Homestead an elongate mass of pink granite forms a low but rugged range of hills which culminates at its southeastern end in Mount Glengalder. The granite intrudes the Cape River Beds parallel to their foliation. It consists of quartz (35%), microperthite (35-40%), oligoclase (10-15%), and biotite (5%). At its northern end it is foliated parallel to the Deadman Fault Zone. At Mount Glengalder, slightly foliated quartz-feldspar porphyry crops out at the margin of the granite near a parallel fault zone.

An elongate stock of massive medium to coarse biotite granite crops out southwest of Mount Misery, west of Homestead. The granite has been intruded parallel to the foliation in the Cape River Beds, and consists of microperthite (50%), quartz (40%), oligoclase (5%), and biotite (5%). It gives rise to undulating sand-covered rises with little outcrop, but has been exposed during reconstruction of the Great Northern Railway.

Coarse red biotite granite forms small steep hills 5 miles west of River View homestead. A weak foliation in the granite dips steeply to the north, and a vague lineation of mineral grains plunges at about 20° to the east. Near Larry Creek the granite has been weakly greisenized. Little is known of the relationships of this granite, but it is probably nonconformably overlain by the Betts Creek Beds (Upper Permian).

A mass of white medium-grained biotite adamellite containing distinctive lobate quartz crystals intrudes the main granodiorite phase at the southeastern end of the Tuckers Range. The adamellite is intruded by the Tuckers Igneous Complex (Carboniferous to Permian). A stock of coarse red leucocratic alkali granite crops out 1 mile to the south of the adamellite.

Glenell Granodiorite (new name)

The Glenell Granodiorite (Clarke, 1969, unpubl., and Appendix 3 of this Report) intrudes the main granodiorite phase. It extends north into the Townsville Sheet area, but was not recognized there in the course of the regional mapping. It is a massive medium-grained grey porphyritic hornblende-biotite granodiorite with a uniform composition and texture. It contains abundant quartz phenocrysts. The granodiorite is generally strongly sericitized, and the biotite is almost always strongly chloritized.

The contacts with the main granodiorite phase are sharply defined. The Glenell Granodiorite is intruded by the Millaroo Granite. The contact with the Mosgardies Adamellite is sheared, but the adamellite is thought to be younger than the granodiorite because of the abundance of granite dykes in the Glenell Granodiorite near the contact. Numerous felsite and microdiorite dykes intrude the Glenell Granodiorite.

A few auriferous quartz reefs occur in the Glenell Granodiorite near the Millaroo Granite, and the gold mines at Grass Hut in the Townsville Sheet area are situated in the main granodiorite phase next to the contact of the Glenell Granodiorite.

Two of the specimens which define the 454 m.y. Rb/Sr isochron (Appendix 2) were collected from the Glenell Granodiorite. Hornblende from a third has given a K/Ar age of 426 m.y., which suggests that argon leakage occurred during the later (395 m.y.) magmatic phase.

Mosgardies Adamellite (new name)

The Mosgardies Adamellite (Clarke, 1969, unpubl., and Appendix 3 of this Report) is an east-west body, 6 miles long and up to 2 miles wide, which forms sparsely timbered rocky hills a few miles west of Ravenswood. It consists mainly of pink medium-grained porphyritic biotite adamellite, containing ovoid quartz phenocrysts up to 1.5 cm and characteristic felted aggregates of fine biotite flakes. Along its northern margin the adamellite grades into quartz porphyry. Microgranite and some granophyre and granite occur in the northwest, mainly as dykes.

The Mosgardies Adamellite intrudes the main granodiorite phase with a strongly sheared contact which dips gently to the north. By contrast, the contact with the Glenell Granodiorite is straight, and probably nearly vertical. This contact is also strongly sheared. One of the specimens which define the 454 m.y. Rb/Sr isochron was collected from the Mosgardies Adamellite.

Millaroo Granite (new name)

The Millaroo Granite (Clarke, 1969, unpubl., and Appendix 3 of this Report) forms a sparsely vegetated range which occupies 40 square miles of the Sheet area north of Ravenswood, and extends into the Townsville Sheet area. It ranges from coarse porphyritic calc-alkali granite, containing oligoclase and 4 percent biotite, to medium-grained leucocratic calc-alkali granite, containing andesine and minor biotite, and in places it grades into adamellite, granophyre, and microgranite with quartz phenocrysts. The numerous dykes of graphic granite and microgranite which intrude the main granodiorite phase next to the Millaroo Granite are probably related to the granite.

'70—3

The Millaroo Granite intrudes the Kirk River Beds, Mount Windsor Volcanics, the main granodiorite phase, and Glenell Granodiorite. The contacts of the Millaroo Granite are generally not sheared. In the southwest the granite apparently overlies the Glenell Granodiorite, and the contact dips gently to the northeast. North of Ravenswood, however, the contact between the Millaroo Granite and the main granodiorite phase appears to dip south. The Millaroo Granite has a Rb/Sr age of 454±30 m.y.

Kirklea Granite (new name)

The Kirklea Granite (Clarke, 1969, unpubl., and Appendix 3 of this Report) is a uniform medium to coarse calc-alkali granite which forms low ranges between Pandanus Creek and the Kirk River. Fine-grained aplitic granite occurs near the margins in a few places. The granite intrudes the main granodiorite phase with a sharp contact, which in places is interpreted as dipping gently inwards, the granite overlying the country rock. North-northwesterly faults, marked by wide zones of breccia and silicification, cut the Kirklea Granite and surrounding granodiorite. Along the southern margin of the granite many of these fractures contained the gold mineralization which was worked from the abandoned township of Kirk. One specimen of the Kirklea Granite gave a Rb/Sr age of 454±30 m.y.; another gave a biotite K/Ar age of 397 m.y., which, when considered in the light of the later 395 m.y. intrusive spoch, suggests the total loss of earlier formed radiogenic argon.

UPPER SILURIAN OR LOWER DEVONIAN
(Table 3)

Barrabas Adamellite
(new name)

Like the named subunits of the Ravenswood Granodiorite Complex, the Barrabas Adamellite is described more fully by Clarke (1969, unpubl.,) and its characteristics are only summarized in this Report. It is formally defined by Clarke in Appendix 3. It forms 20 square miles of sparsely vegetated sandy country between Connolly Creek and Barrabas Scrub southwest of Ravenswood. Apart from a few scattered tors of fresh rock, it is deeply weathered.

The Barrabas Adamellite consists mainly of medium to coarse biotite adamellite, which grades into granite and granodiorite, and a little leucoadamellite and microgranite. The granite occurs only in the southwestern part of the intrusion. The Barrabas Adamellite is similar to the western part of the Lolworth Igneous Complex.

It intrudes the main granodiorite phase of the Ravenswood Granodiorite Complex. Adamellite dykes are common within the Barrabas Adamellite, and an abundance of adamellite dykes southwest and west of the main mass suggests that it may extend beneath this area at depth. Masses of quartz, in places containing some feldspar crystals, crop out near the margin of the intrusion and in the surrounding country rock. Northeast-trending zones of breccia or mylonite are common in the eastern part of the intrusion. Quartz-tourmaline pegmatite veins are associated with the breccias.

Two specimens of the Barrabas Adamellite gave a Rb/Sr age of 394±30 m.y. and biotite from a third gave a K/Ar age of 397 m.y.

Lolworth Igneous Complex
(new name)

The Lolworth Igneous Complex (see also Paine et al., 1965, unpubl., and in prep.) is a composite batholith which crops out in the northeastern part of the Hughenden Sheet area, where it forms the Lolworth Range, and in the northwestern part of the Charters Towers Sheet area. It is about 500 square miles in extent, of which 200 square miles are in the Charters Towers Sheet area. The complex forms a belt of hills between the Flinders Highway and the basalt plains to the north. It gives rise to broken country with a relief of up to 800 feet in the headwaters of Homestead Creek, which gradually decreases eastwards. The complex is partly covered by a dissected veneer of Cainozoic sandstone and conglomerate (Campaspe Beds). The deeply lateritized granitic rocks which crop out north of Glen Dillon homestead have been included in the complex.

In the Charters Towers Sheet area the Lolworth Igneous Complex consists mainly of pink or white banded pegmatitic and garnetiferous muscovite granite or adamellite. The quartz content ranges from 40 to 45 percent, microperthite from 20 to 40 percent, oligoclase from 10 to 20 percent, and muscovite is normally about 5 percent. Very little biotite is generally present, but it ranges up to 5 percent in places. Small euhedral pink crystals of garnet are almost ubiquitous. Oligoclase forms from 17 to 50 percent of the total feldspar. One specimen, however, is a muscovite microtrondhjemite composed of oligoclase (50%), quartz (40%), microcline microperthite (5%), and muscovite (5%).

The texture ranges from aplitic to graphic and pegmatitic, and in places phenocrysts of feldspar are present in an aplitic groundmass. The phenocrysts are commonly 5 to 8 cm long, but rare crystals up to 30 cm have been noted. The granite is characteristically banded. The banding is a primary feature and is due to variations in grainsize, texture, and composition. Individual bands range from a fraction of a centimetre to over 5 cm thick, and rarely up to about 1 metre. Muscovite is concentrated in some bands and absent in others; where present it has generally crystallized in a dendritic form normal to the banding. Some of the thin bands contain a high proportion of small even-grained crystals of garnet.

The banding is folded and generally dips at low to moderate angles, but even in a single outcrop it may form open sinuous folds which have no consistent plunge.

Sheets of garnetiferous muscovite pegmatite, aplite, and granite up to 20 feet thick intrude the granite and adamellite; they cut across the primary banding, and commonly dip at low angles. The sheets also intrude the Cape River Beds and Ravenswood Granodiorite Complex near the contact.

Two other small areas of slightly different granitic rocks have been included in the complex. They comprise a white massive coarse biotite-muscovite granite or adamellite which crops out in a narrow belt between Oaky Creek and the Pentland Hills, and a lateritized coarse porphyritic 'granite' similar to the porphyritic adamellite in the Hughenden Sheet area, which forms the country rock at the abandoned Big Hit mine, north of Glen Dillon homestead.

The Lolworth Igneous Complex intrudes the Cape River Beds and Ravenswood Granodiorite Complex, and is intruded by the Upper Permian(?) Mundic Igneous Complex. Unlike much of the Ravenswood Granodiorite Complex nearby the Lolworth Igneous Complex is not foliated and is therefore regarded as a post-orogenic batholith. The southern margin of the complex transgresses the trend of the foliation in the Cape River Beds and coincides with the Deadman Fault Zone. The muscovite granite in this zone is not foliated, whereas the Ravenswood Granodiorite Complex is strongly foliated in the fault zone. This suggests that the fault was active before the Lolworth Igneous Complex was intruded, and it may have localized the southern margin of the complex.

Isotopic dating has shown that the Lolworth Igneous Complex was intruded at the close of the Silurian or beginning of the Devonian (400 m.y.), at the same time as the Barrabas Adamellite and the younger intrusions of the Ravenswood Granodiorite Complex.

Gold, lead, copper, and arsenic mineralization is associated with the Lolworth Igneous Complex at the Old Homestead diggings in the headwaters of Homestead and Deadman Creeks. Later movements on the Deadman Fault Zone may have played a part in localizing this mineralization. Gold and base metal sulphide deposits occur in the Lolworth Igneous Complex at Lolworth diggings near Mount Stewart in the Hughenden Sheet area. These deposits have been tentatively regarded as genetically related to the Mundic Igneous Complex (Paine et al., 1965, unpubl., and in prep.). However, similar auriferous greisen pipes to those at Lolworth diggings occur at the Big Hit mine, 30 miles northeast of the nearest outcrops of the Mundic Igneous Complex. Therefore it is equally possible that both this and the Lolworth deposits are genetically related to the Lolworth Igneous Complex.

Close of the Early Palaeozoic

From the Upper Silurian to the Lower Devonian the Burdekin River region was subject to orogenic uplift accompanied by granitic intrusion (Wyatt & Jell, 1967). These intrusions began with the Dido Granodiorite in the Clarke River Sheet area (405 ± 21 m.y., Richards et al., 1966), continued with the Lolworth Igneous Complex (400 m.y.) and the younger group of intrusions in the Ravenswood Granodiorite Complex (395 m.y.), and ended with the Dumbano Granite (380 ± 8 m.y., Richards et al., 1966). This orogeny, which is equivalent to the Bowning orogeny of southeast Australia, brought to a close an era of sedimentation that was essentially geosynclinal in type. This early era of sedimentation and igneous intrusion is called 'early Palaeozoic' in this and other reports on the geology of the Burdekin River region (Wyatt et al., 1969; Paine et al., 1969; Paine et al., 1965, unpubl., and in prep.), whereas Palaeozoic rocks of Middle Devonian and younger age are referred to as 'late Palaeozoic'.

The Upper Silurian/Lower Devonian orogeny welded the early Palaeozoic strata to the Precambrian craton so that, during the remainder of the Palaeozoic, sedimentation was essentially of shelf or intracratonic type. This later sedimentary cycle commenced in the lower Middle Devonian in the southeastern part of the Charters Towers Sheet area (Ukalunda Beds), and in the upper Middle Devonian in the Townsville Sheet area (Fanning River Group). The two depositional areas were separated by the Lolworth-Ravenswood Block, a structural high which consisted of the deeply eroded Ravenswood Granodiorite Complex and early Palaeozoic sediments and volcanics. The Lolworth-Ravenswood Block was the provenance for the Fanning River Group and succeeding strata, and probably also for the Ukalunda Beds.

UNDIVIDED PALAEOZOIC
(Table 4)

Acid Volcanics (Pzo)

The volcanics of unknown age and association at Mount Leyshon, 15 miles south of Charters Towers, have been mapped as a separate unit. They have been described by Jack (1885), Rands (1891), and Morton (1932b).

Hills of rhyolite, rhyolite and dacite porphyry, agglomerate, and volcanic breccia represent volcanic necks which have been intruded into the Ravenswood Granodiorite Complex (O-Da) and the Cape River Beds.

The volcanics contain abundant sulphides which occur both as disseminations and as thin veins filling fractures. Oxidation of the sulphides has altered the appearance of the rocks to such an extent that they cannot be correlated with other volcanics in the area younger than the Ravenswood Granodiorite Complex.

Dykes of altered flow-banded quartz-feldspar porphyry, which are possibly related to the Mount Leyshon volcanic centre, occur in the granodiorite northeast of Mount Leyshon. The dykes are partly greisenized and stained by iron oxides along partings parallel to the flow banding.

MIDDLE DEVONIAN
(Table 4)

Ukalunda Beds

The Middle Devonian is represented by the Ukalunda Beds (Malone et al., 1966) which extend into the extreme southeastern corner of the Charters Towers Sheet area from their type area in the Bowen Sheet. They give rise to low hills with a fairly close drainage pattern which has no obvious structural control.

In the Charters Towers Sheet area the Ukalunda Beds consist of grey-brown hematitic siltstone and fine greywacke, but they are extensively metamorphosed to phyllite near the border of the Sheet area. Rare hornfels is interbedded with the phyllite, and in the Bowen Sheet area, a few miles to the east, the beds are pervasively intruded by granite. The phyllites are cut by swarms of quartz veins, many of which have been folded and boudinaged. Very close jointing in the phyllite has given rise to 'pencil-rodding' which plunges at 20^{0} to the south-southwest (Fig. 7). Bedding was not recognized in the Ukalunda Beds owing to the cleavage, and neither the general structure nor thickness is known.

Marine fossils from the Ukalunda Beds in the Bowen Sheet area indicate a lower Middle Devonian age (Hill et al., 1967). A moderately deep-water environment of deposition is suggested by Malone et al. (1966).

The Ukalunda Beds are unconformably overlain by the St anns and Scartwater Formations (Olgers et al., 1967, unpubl.), although strike faults and Cainozoic sediments obscure the unconformity in the Charters Towers Sheet area.

UPPER DEVONIAN TO LOWER CARBONIFEROUS
(Table 4)

Drummond Basin Succession

Up to 25,000 feet of continental sediments and volcanics were laid down in the Upper Devonian and Lower Carboniferous periods in the Drummond Basin, whose northern end occupies the southeastern quarter of the Charters Towers Sheet area.

The Drummond Basin is a meridional structure which extends north for 250 miles from the Nogoa River (Springsure Sheet area) to within 40 miles of Charters Towers. The name Drummond Beds was first used by Jack (Jack & Etheridge, 1892) for the rocks of the Drummond Range, including those at Boguntungan (Emerald Sheet area), from which Tenison Woods (1883) determined Lepidodendron sp. Jack regarded the rocks as Permo-Carboniferous. Reid (1930) mapped other outcrops of the succession and referred to it as the Drummond Series of Upper Devonian to Lower Carboniferous age. Hill, in the Geological Map of Queensland (1953) referred to the series as the Drummond Group. Tweedale (in Hill & Denmead, 1960), summarized knowledge of the succession up to 1960.

The northern end of the Drummond Basin was mapped by the Charters Towers field party in 1964, and the results were presented in an unpublished report on the geology of the Charters Towers Sheet (Wyatt et al., 1967, unpubl.). No attempt was made to erect separate formations in view of an impending regional study of the Drummond Basin by F. Olgers and

TABLE 4. DEVONIAN TO LOWER CARBONIFEROUS STRATIGRAPHY AND IGNEOUS ACTIVITY

Age		Rock Unit (References)	Lithology	Remarks
LOWER CARBONIFEROUS	DRUMMOND GROUP	Natal Formation Cln (1-3)	Alternating fine feldspathic quartz sandstone and olive siltstone	Conformable on Clb. Shallow fresh water, possibly lacustrine. Poorly preserved plants. Over 4000 ft thick
LOWER CARBONIFEROUS	DRUMMOND GROUP	Bulliwallah Formation Clb (1-3)	Fine to medium feldspathic quartz sandstone; minor olive mudstone, pebbly feldspathic quartz sandstone, and algal limestone	Conformable on Cls. Shallow fresh water, possibly lacustrine. Poorly preserved plants; algae. 6000 ft thick
LOWER CARBONIFEROUS	DRUMMOND GROUP	Star of Hope Formation Cls (1-3)	Lapilli tuff, welded tuff, tuffaceous sandstone, volcanolithic sandstone, sandstone with quartz pebbles, conglomerate	Conformable on Clr. Fluvial. Plant fossils and possible pelecypods (White, 1967, unpubl.). Up to 6000 ft thick
LOWER CARBONIFEROUS	DRUMMOND GROUP	Raymond Formation Clr	Fine to medium quartz sandstone, locally feldspathic; interbeds of clayey sandstone and mudstone	Mainly conformable on Clh. Fluvial; probably mainly over-bank deposits. Plants. 2000-5000 ft. thick
LOWER CARBONIFEROUS	DRUMMOND GROUP	Mount Hall Formation Clh (1-3)	Pebbly and conglomeratic quartz sandstone, coarse quartz sandstone	Conformable on DCw. Fluvial; mainly point bar deposits. Wood fragments. 0-8000 ft thick
	DRUMMOND GROUP	Scartwater Formation D/Cw (1-3)	Fine fesdspathic sandstone with interbeds of calcarenite, algal limestone, olive mudstone, lithic tuff, and tuff	Probably unconformable on D/Ca. Fluvial, but possibly partly marine. Plants. 1000-4000 ft thick

Age	Rock Unit (References)	Lithology	Remarks
U.DEVONIAN TO L.CARBONIFEROUS	St Anns Formation D/Ca (1-3)	Acid and intermediate volcanics and algal limestone at top; labile sandstone; minor green mudstone and phosphatic sandstone	Unconformable on Dk. Shallow water. Lower part possibly marine; upper part terrestrial. Plants, algae, wrm casts. 7000 ft thick
	D/Cv (3)	Acid and intermediate volcanics; some micaceous labile arenite	Nonconformable on O-Da. Unconformably overlain by Clr. Thickness unknown
M. DEVONIAN	Ukalunda Beds Dk (4, 5)	Phyllite, siltstone, fine greywacke	Unconformably overlain by D/Ca. Intruded by granite in Bowen Sheet area, with associated minor gold, silver, copper, arsenic, and bismuth
UNDIVIDED PALAEOZOIC	Pzo (5-9)	Rhyolitic and dacitic porphyry; agglomerate	Volcanic necks. Emplaced at contact of Cape R Beds and Ravenswood Granodiorite Complex. Gold (Mt Leyshon)

Principal references: (1) Olgers et al. (1967, unpubl.); (2) Olgers (1969); (3) Olgers (in prep.); (4) Malone et al. (1966); (5) This Report; (6) Jack (1885); (7) Rands (1891); (8) Morton (1932b); (9) Murray & Hartly (1960).

Fig. 7. 'Pencil-rodding' in cleaved siltstone, caused by several intersecting sets of joints which have a common strike. Two further joint sets, more widely spaced than those giving rise to the lineation, dip to the right, one beneath the wristwatch, the other striking at right angles to the plane of the photograph. Ukalunda Beds, in bed of gully 6.5 miles SSE of Arthur Plains homestead.

others in 1966-67. The succession was mapped as a single unit, and called Drummond Group. In order to facilitate description the group was subdivided informally into four lithological subunits, whose distribution was shown on a sketch map in the report. Owing to complex structure, facies changes, and the unfamiliarity of the Charters Towers party geologists with the sequence in the main part of the Drummond Basin, the lithological subunits of the 1967 unpublished report do not correspond well with the formations as later traced northwards by Olgers and others from type areas farther south. Therefore no useful purpose would be served, and confusion created, by publishing in this Report the earlier description of the Drummond Basin succession. For a full account of the geology of the basin the reader is referred to Olgers (1969, in prep.). An abbreviated account of Olgers' results follows here, and is supplemented in Table 4. The St Anns, Star of Hope, Mount Hall, Raymond, Bulliwallah, and Natal Formations are named and defined by Olgers (1969, in prep.).

The St Anns Formation, which is broadly equivalent to the Mount Wyatt Beds of the Bowen Sheet area (Malone et al., 1966), rests unconformably on the Ukalunda Beds, and together with an equivalent but unnamed volcanic unit (D/Cv) farther north marked the onset of deposition in the Drummond Basin (Olgers et al., 1967, unpubl.; Olgers, 1969, in prep.). The Drummond Basin succession is essentially Lower Carboniferous, but the

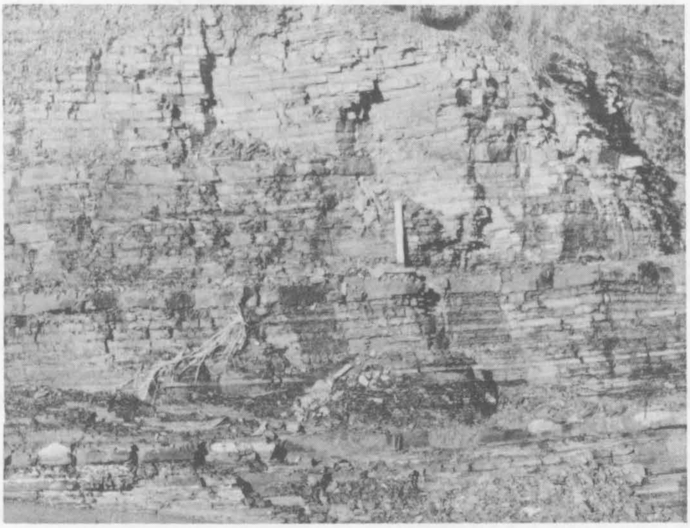

Fig. 8. Regularly bedded siltstone of the Scartwater Formation, 3.5 miles SW of Cranbourne homestead. The thinner beds are reddish brown, and the thicker beds are grey and slightly macaceous.

St Anns Formation and the unnamed volcanic unit (D/Cv) may be Upper Devonian. Photogeological evidence indicates that the Scartwater Formation (Fig. 8) possibly overlies the St Anns Formation with a slight unconformity. The Scartwater Formation is the oldest formation at the northern end of the basin that contains abundant lithic and feldspathic quartz sandstone and green mudstone which are characteristic of the Drummond Group. There are only two major breaks in this type of sedimentation in the Drummond Group, namely the pebbly quartz sandstone/conglomerate sequence of the Mount Hall Formation and the acid volcanics/conglomerate sequence of the Star of Hope Formation.

The Mount Hall Formation overlies and interfingers with the Scartwater Formation. In the north, the Raymond Formation apparently overlaps the Mount Hall Formation and directly overlies the Scartwater Formation. The Star of Hope Formation, which contains the products of renewed vulcanism, overlaps both the Raymond and Mount Hall Formations and at the eastern margin of the Sheet area it also directly overlies the Scartwater Formation. The Scartwater, Mount Hall, Raymond, and Star of Hope Formations were laid down in a large river system. The palaeocurrent directions in the Mount Hall Formation (channel deposits) are southwesterly and southerly in the Charters Towers Sheet area; throughout the rest of the basin they are northerly, except in the northeastern corner of the Buchanan Sheet area where they swing abruptly to the east. The abrupt change in direction shows that the connexion with the sea in the Lower Carboniferous was across the northern part of the Anakie Inlier (Mount Coolon Sheet). Along the northern margin of the basin the units overlap progressively to the west, and in the centre of the Sheet area the Star of Hope Formation rests directly on the Cape River Beds.

The development of a probable lacustrine environment is expressed by the Bulliwallah and Natal Formations, which are best exposed in the Buchanan Sheet area.

The Drummond Basin sequence is not metamorphosed. The fold axes in the basin generally trend northeast. There is a variety of styles of folding, reflecting a northward continuation of the several structural domains described by Olgers et al. (1967, unpubl.). Open synclines are developed in the southeast, tight folds between the Cap and Sutor Rivers and north of the Cape River, gentle undulations with no regional trend in a shelf zone along the northern margin, and uniform westerly dipping strata in the west. The zone of tight folding is strongly faulted.

The fossils collected in 1964 from the unnamed volcanics (D/Cv) and the Drummond Group are described by R.G. McKellar in Appendix 1. Further collections were made by F.Olgers and party in 1966-67; these have been described by Mary E. White (1968, unpubl.). In the same report, for comparative purposes, Mrs White has also described the fossils collected in 1964.

LOWER CARBONIFEROUS

Hornblende Porphyrite Dykes

Reid (1917) described several hornblende porphyrite dykes near Charters Towers; his report includes petrological descriptions and one chemical analysis. Jack (1879) mentioned that a porphyry dyke 'runs -------- through the (Old Identity) reef' and from his description of the dyke's attitude, it is evident that the porphyry is the same as one of Reid's hornblende porphyrites. These dykes are thus post-mineralization in age.

Five specimens from two of these dykes have given an average K/Ar age of 330 m.y. (Webb, 1969), which indicates a Lower Carboniferous - probably late Visean - age.

UPPER CARBONIFEROUS
(Table 5)

Acid to Intermediate Volcanics (Cuv)

Isolated areas of acid to intermediate lavas and pyroclastics crop out in the northeast. All are younger than the Ravenswood Granodiorite Complex, and those at Camp Oven Mountain are younger than the Scartwater Formation (Upper Devonian or Lower Carboniferous). They resemble and may be equivalent to the late Upper Carboniferous Bulgonunna Volcanics in the Bowen Sheet area. The occurrences are discussed below.

Acid lavas and minor pyroclastics form a northeasterly trending belt transected by the Burdekin River 15 miles east of Charters Towers. South of the river, the flows appear to dip gently away from the intrusive rhyolite of The Cornishman (Cur), with which they are apparently associated. North of the river several square miles of sub-horizontal andesite and rhyolite flows and pyroclastics occur southwest of the Tuckers Range (Clarke, 1969, unpubl.); they appear to be a continuation of those on the south side of the river.

Camp Oven Mountain consists of several arcuate ridges around a central depression. The sequence inwards towards the depression is dark blue-grey andesite, medium to coarse-grained pyritic andesite, light creamy purple flow-banded rhyolite with phenocrysts of feldspar and biotite, tuff, and rhyolite breccia and agglomerate. Rhyolite and rhyolite agglomerate predominate, the agglomerate forming the most prominent ridges. In the central depression, which is probably an old volcanic vent, rhyolite breccia, welded tuff(?), and agglomerate accompany andesite, andesite tuff, and porphyritic andesite. To the west of the vent the volcanics dip vertically or steeply outwards, but in the southeast they appear to dip towards the vent. A small faulted outlier of the Scartwater Formation, which occurs in the depression, is intruded by rhyolite dykes related to the volcanics.

The numerous rhyolite and andesite dykes in the country surrounding Camp Oven Mountain are probably related to the volcanics.

TABLE 5. UPPER CARBONIFEROUS AND PERMIAN STRATIGRAPHY AND IGNEOUS ACTIVITY

Age		Rock Unit (References)	Lithology	Remarks	
UPPER PERMIAN	Mundic Igneous Complex	Pum_3 (1)	Drusy leucogranite	Epizonal stock. Forms rugged Pentland Hills. Intrudes Cape R Beds, Pum_2, and Pum_1	May be related to gold and minor copper, lead, zinc, tungsten, arsenic, bismuth, and molybdenum mineralization at Lolworth diggings in Hughenden Sheet area. See Table 7
		Pum_2 (1, 2)	Minor intrusives ranging from dolerite to microgranite	Small bosses and bodies of unknown shape. Some roof-pendants on Pum_3, some intrude Pum_1, others intrude Lolworth Igneous Complex	
		Pum_1 (1)	Volcanic breccia; some dacite and rhyolite	Crudely bedded on NW flank of Pentland Hills. Nonconformable on Lolworth Igneous Complex	
		Betts Creek Beds Pub (1, 3-5)	Lithic sandstone and mudstone; in places tuffaceous; quartzose conglomerate	Unconformable on Ravenswood Granodiorite Complex; overlain by Warang Sst with regional unconformity. Outwash plain or piedmont deposits. Indeterminate plant remains. Coal seams in Hughenden Sheet area. 400 ft thick	
		C-Pg	Granodiorite, adamellite, granite	Epizonal stocks near E edge of Sheet area. Intrudes Ravenswood Granodiorite Complex, C-Oc, D/Ca, and Drummond Gp. Very minor gold and molybdenum. C-Pg_1 intrudes C-Pg. See Table 6	
		C-Pg_1	Biotite adamellite		

Age		Rock Unit (References)	Lithology	Remarks	
		C-Py (1, 6,7)	Rhyolite, rhyolite breccia	Volcanic plug reforming Mt Cooper. Intrudes Ravenswood Granodiorite Complex	
		C-Pi (1)	Altered diorite, gabbro, dolerite	Numerous irregular and sill-like bodies intrusive into D/Ca and Drummond Gp. Generally weathered to black soil	
U. CARBONIFEROUS TO L. PERMIAN	Boori Igneous Complex	C-Pb_3 (8)	Biotite-hornblende granodiorite, adamellite	Resembles C-Pt_2. Intrudes C-Pb_2	Intrude
		C-Pb_2 (8)	Tonalite, minor diorite	Intrudes C-Pb_1 with shearing along contact. Resembles C-Pt_1	
		C-Pb_1 (8)	Leucogranite	Intrudes Cur. Possibly not related magmatically to rest of complex	
	Tuckers Igneous Complex	C-Pt_4 (8)	Leucogranite, leucoadamellite	Final differentiate of intrusion. Dykes, veins, and small marginal masses	Ravenswood
		C-Pt_3 (8)	Granodiorite, minor adamellite	Double sheet intrusion, sheets converge at depth. Intrudes C-Pt_2 and C-Pt_1	Granodiorite
		C-Pt_2 (8)	Biotite-hornblende granodiorite, minor tonalite	Main part of Tuckers Ra. Intrudes Cuv	Complex and Cuv
		C-Pt_1 (8)	Gabbro, diorite, mangerite, minor granodiorite	Intrudes Cuv; intruded by or possibly gradational with C-Pt_2. Develops largely black soil	

Age	Rock Unit (References)	Lithology	Remarks
U. CARBONIFEROUS	Cur (1, 8)	Rhyolite, quartz-feldspar porphyry, quartz porphyry; minor dacite, trachyandesite, andesite, and rhyolite breccia	Small intrusive masses, plugs, and sheets. Possibly volcanic feeders related to Cuv. Intrudes C-OW$ Ravenswood Granodiorite Complex, D/Ca, and Drummond Gp. Copper-molybdenum mineralization at Titor prospect
	Cuv (1, 8)	Rhyolite, agglomerate, andesite, tuff, volcanic breccia; minor labile conglomerate and finer-grained sediments	Overlies Ravenswood Granodiorite Complex. Post-dates Drummond Gp at Camp Oven Mountain. Intruded by C-Pt and C-Pb. Unfossiliferous

Principal references: (1) This Report; (2) Paine et al. (1965, unpubl.); (3) Vine et al. (1964, unpubl.); (4) Evans (1964, unpubl.); (5) White (1964, unpubl.); (6) Rands (1891); (7) Maclaren (1900); (8) Clarke (1969, unpubl.).

Ten miles southeast of Ravenswood, in the headwaters of Connolly Creek, a sequence of rhyolite, rhyolite breccia, coarse bluish black welded tuff, and dacite and andesite breccia form a narrow arcuate plateau. The sequence is steeply dipping, and on the air-photographs it appears to form an arcuate syncline trending north to northeast. The welded tuff consists of scattered subrounded fragments of felsite, spherulitic in places, set in a matrix of devitrified glass shards. The fragments range up to 1.5 cm in diameter.

One mile southeast of Mount Canton, in the Robey Range, an area of about 5 square miles is occupied by volcanics and associated sediments. The sequence was only briefly examined at the northwestern margin of the mapped area, where it consists mainly of conglomerate. The conglomerates are massive and contain pebbles and cobbles of porphyritic rhyolite, granite, and labile arenites similar to those interbedded with the Mount Windsor Volcanics in Fish Creek. Most of the cobbles are well rounded. A few beds of well bedded tuff and tuffaceous silty shale and some rhyolite flows are interbedded with the conglomerate. Granite crops out in places between the ridges of conglomerate.

On the northwestern margin of the mapped area the sediments dip at 80° to the north-west and are faulted against the Stony Creek adamellite stock (C-Pg). Faint trend-lines are visible on the air-photographs in the eastern part of the mapped area.

The northeastern member of The Twins (18 miles south-southeast of Mount Canton) is composed of weathered brown and greenish brown porphyritic rhyolite and possibly intrusive quartz-feldspar porphyry. The rocks are brecciated in places, and some of the fragments are coated with pyrite. Near the telegraph line northeast of The Twins the rhyolite is flow-banded; the banding is vertical and strikes northwest.

Intrusive Rhyolite and Porphyry (Cur)

A number of isolated intrusive bodies, composed mainly of flow-banded rhyolite, have been mapped in the Sheet area; they are probably related to the Upper Carboniferous(?) volcanics. Most of them are confined to a belt between Camp Oven Mountain in the north-east and Mount Malakoff in the southwest. Other occurrences are at Cornishman Hill near Broughton, at Mount Stone in the southeastern corner of the Sheet area, and at several scattered localities in the Ravenswood 1-mile Sheet area.

At Mount Bellevue and near Pallamana homestead the rhyolites are largely concealed by laterite, but elsewhere they form hills which vary from a few tens of feet above the surrounding country to several hundred feet. On the air-photographs they do not always show a distinctive pattern or tone, and they commonly support a thin cover of broad-leafed ironbark trees. Six miles west of Camp Oven Mountain a mass of flow-banded rhyolite, measuring about 3 miles by 2 miles, intrudes the Cape River Beds. Poorly consolidated medium-grained yellow to pink tuffs crop out in a small creek on the south-western margin of the rhyolite. The tuffs contain grains of quartz and fragments of acid porphyry and fine-grained andesite. A rhyolite dyke intrudes the Cape River Beds half a mile north of the main mass. It trends northeast subparallel to the margin of the main intrusion.

The irregular mass of rhyolite in the Cape River Beds 5 miles west-southwest of Camp Oven Mountain consists of thick sills which extend to the northeast and southwest of a small central body. In a tributary of Pinnacle Creek a sill 150 feet thick is exposed. Within 4 feet of the lower contact the rock has a flow-banded rhyolitic texture, but it passes upwards into a fine white porphyry with phenocrysts of rounded quartz and orange feldspar up to 1.5 mm across. There is a strong joint system normal to the contact.

The Three Sisters 4 miles north-northwest of Mount Cooper consist of a number of quartz porphyry dykes and irregular intrusions cutting the Ravenswood Granodiorite Complex.

Near Pallamana homestead a low ridge of rhyolite a few hundred yards wide trends southwest. The rhyolite is purplish brown and strongly flow-banded, but locally it is spherulitic, porphyritic, and autobrecciated. The flow banding is vertical where the rhyolite intrudes the Raymond Formation at the southwestern end of the ridge. The rhyolite is strongly fractured, generally at right angles to the flow banding, and the fractures are filled by red jasperoid material.

Near New Victoria Downs homestead a group of low hills, also called the Three Sisters, is composed of flow-banded rhyolite. The rhyolite contains glomeroporphyritic clusters of quartz phenocrysts in a felsitic groundmass. The flow banding is very contorted and generally nearly vertical. Similar rhyolite occurs in a washaway 2 miles southwest of Slogan Downs homestead. Mount Raglan is composed of pink holocrystalline porphyritic flow-banded rhyolite. The flow banding is contorted and steeply dipping. Mount Bellevue consists mainly of purple porphyritic flow-banded dacite. The banding is generally contorted and steeply dipping, and consists of layers of holocrystalline material separated by layers of glass 1 mm thick. Northeast of Mount Malakoff are a number of low hills composed of flow-banded fine-grained porphyritic trachyandesite which appear to intrude the Star of Hope Formation. Again, the flow banding is contorted and steeply dipping.

Mount Stone, 5 miles south of Mount McConnell homestead, is composed of pinkish buff to white spherulitic rhyolite.

The Cornishman south of Broughton is composed of flow-banded rhyolite and porphyritic rhyolite which intrude the Ravenswood Granodiorite Complex. Breccia occurs at the contact, and, west of the hill, dykes from the main mass intrude the granodiorite. Many of the dykes have a curvilinear trend, subparallel to the margin of the main mass. The rhyolites probably form the plug of a volcano from which the acid lavas immediately to the east of The Cornishman were extruded.

The summit of Blue Mountain, 5 miles north of Ravenswood, appears to consist of rhyolite. The rocks were seen only from a light aircraft, but have the general colour, joint system, and rugged topography of the intrusive rhyolites in the Townsville Sheet area.

Numerous irregular dykes of light grey acid volcanic(?) breccia crop out in a brecciated and mylonitized late granite phase of the Ravenswood Granodiorite Complex 5 miles north-northeast of Mount Cooper. The breccia consists of quartz (10%), feldspar (15%), clinopyroxene and hornblende (5%), minor tourmaline, and abundant lithic fragments (chiefly red acid granite, basic volcanics, hornfels, chlorite schist) set in a very fine matrix which has been altered to clay. The source of the lithic fragments (except for the granite) is unknown.

A small intrusion of red quartz-feldspar porphyry cuts the Star of Hope Formation 3 miles north of Mount McConnell homestead, and an arcuate intrusion of red porphyry has been emplaced along a fault between the St Anns Formation and the Ukalunda Beds near Fairview Hill. F. Olgers (pers. comm.) regards the Fairview Hill occurrence as part of a ring-like fault-controlled feeder related to the Bulgonunna Volcanics in the Bowen Sheet area.

The irregular porphyry and rhyolite intrusions (too small to map) cutting the unnamed volcanics (D/Cv) north of Cranbourne homestead are intruded by andesite dykes.

The Titov disseminated and veinlet-type copper and molybdenum prospect 10 miles northwest of Ravenswood is centred on a low rise formed from a small intrusion of feldspar-quartz porphyry.

UPPER CARBONIFEROUS TO LOWER PERMIAN
(Table 5)

Several epizonal stocks and complexes in the eastern part of the Sheet area are regarded as Upper Carboniferous to Lower Permian in age. Two of them (Tuckers Igneous Complex and Boori Igneous Complex) have yielded K/Ar isotopic ages of about 280 m.y. on biotite (Webb, 1969), which is about the age of the boundary between the Carboniferous and Permian periods. The Tuckers and Boori Igneous Complexes are described in full by Clarke (1969, unpubl.) and are only summarized below. The other late Palaeozoic stocks (C-Pg) are unnamed. All consist of massive unstressed rocks, and are only rarely intruded by dykes.

The sill-like intrusions of altered diorite (C-Pi) in the southeastern part of the Sheet area cut rock units as young as the Star of Hope Formation (Lower Carboniferous), and are provisionally regarded as Upper Carboniferous or Lower Permian. The rhyolite plug of Mount Cooper (C-Py) may be related to the Upper Carboniferous volcanics (Cuv), or alternatively to a group of Upper Permian rhyolite plugs in the Bowen Sheet area (Paine et al., in prep. a).

Tuckers Igneous Complex
(new name)

The Tuckers Igneous Complex (Clarke, Appendix 3, this Report) forms the boulder-strewn Tuckers Range and adjacent black-soil plains. The range has a relief of up to 900 feet. Four phases were mapped by Clarke (see Table 5).

The initial phase (C-Pt_1) consists of gabbro, but at the western end of the complex the gabbro gives way to diorite and mangerite which contain appreciable amounts of potash feldspar. The diorite and mangerite grade into tonalite and granodiorite of the second phase (C-Pt_2), which forms the main part of the Tuckers Range. The third phase, of granodiorite and adamellite, occurs as a bifurcating tabular intrusion, Y-shaped in plan, the two arms of which dip north at converging angles. Dykes, veins, and small bosses of leucogranite and leucoadamellite (C-Pt_4) cut all the other phases of the complex.

The Tuckers Igneous Complex intrudes the Upper Carboniferous(?) volcanics (Cuv) which rest on the eroded surface of the Ravenswood Granodiorite Complex. The successive phases show a progressive increase in the proportion of alkali feldspar and quartz.

Boori Igneous Complex
(new name)

The Boori Igneous Complex (Clarke, Appendix 3, this Report) forms the Kirk Range 10 miles west of Ravenswood. The range is up to 800 feet higher than the surrounding country occupied by the Ravenswood Granodiorite Complex. Three phases were mapped by Clarke (see Table 5).

The initial phase (C-Pb_1) consists of white leucogranite which intrudes volcanics (Cur) east of the Kirk Range. The leucogranite has been sheared, mylonitized, and recrystallized by the intrusion of the second phase (C-Pb_2), which forms the low country along the eastern side of the Kirk Range. All the rocks of the third phase (C-Pb_3) fall within the granodiorite-adamellite range, but granodiorite predominates. Thin dykes and veins of leucoadamellite are common around the margins of the complex, and intrude all phases.

The Boori and Tuckers Igneous Complexes are probably comagmatic. Both complexes postdate the shear zones and dykes cutting the Ravenswood Granodiorite Complex.

Dioritic Intrusives (C-Pi)

Diorite, gabbro, and dolerite occur as partly concordant intrusions in the Upper Devonian and Lower Carboniferous sediments. The intrusions are deuterically altered and generally give rise to black-soil plains.

Two and a half miles northeast of Cranbourne homestead an area of about 3 square miles of black soil contains scattered outcrops of diorite and kindred rocks. About 1 square mile of this area lies in the Charters Towers Sheet area. On the air-photographs the black soil has a characteristic smooth texture and dark grey tone. The rocks are very altered, but medium-grained diorite appears to be predominant. Fine and coarse-grained diorites are also present; the coarser rocks contain plagioclase and hornblende crystals up to 1 cm long. The plagioclase is difficult to identify, and it is possible that gabbro is also present. The original texture and minerals have generally been obliterated by deuteric alteration to prehnite, chlorite, epidote, calcite, clinozoisite, and clay minerals. The development of prismatic quartz crystals up to 2.5 mm long in strongly epidotized narrow bands in the coarser parts, and the development of geodes lined with an outer layer of calcite and an inner layer of prismatic quartz, are probably also the result of deuteric alteration. Some olivine dolerite occurs as blocks in the black soil, but its relationship to the diorite is unknown. The main rock types in the Bowen Sheet area are pyroxene diorite and greenish grey pyroxene monzonite. The monzonite contains numerous small clusters of pink feldspar and quartz with a radial structure.

A 20-foot sill just west of the Green Swamp (north of the junction of the Sellheim and Suttor Rivers) consists of altered greenish grey medium-grained pyroxene diorite.

Several areas of diorite have been mapped between the Cape and Suttor Rivers. A specimen from Bilga Creek (south-southwest of Mount Sebastopol) consists of fine-grained leucocratic biotite-quartz-augite diorite with a granitic to subophitic texture. The occurrence about 7 miles west of Dandenong Park homestead consists of coarse diorite with a granitic texture; the diorite is composed of plagioclase (65%), secondary alteration products (30%), augite (5%), and minor quartz. The alteration products include serpentine, epidote, clinozoisite, chlorite, and calcite. Calcite veins are common in the diorite.

Many individual dioritic intrusions have been photo-interpreted east of the Suttor River. Half a mile northeast of Arthur Plains homestead a uralitized gabbro crops out amongst recrystallized andesitic tuffs of the St Anns Formation. It has an inequigranular texture, and is composed of labradorite (?) (30%), uralitized clinopyroxene (35%), and chlorite, prehnite, and actinolite (35%). Sparse outcrops of altered dolerite occur beside the road 2 miles south of Mount McConnell homestead. The dolerite has a granitic texture and consists of altered andesine-labradorite (65%), clinopyroxene (15%), and serpentine, calcite, epidote, and minor siderite (20%).

Most of these bodies have an irregular outcrop, but between Mount McConnell and Arthur Plains homesteads they are roughly parallel with the strike of the Drummond Group.

The diorites are Lower Carboniferous or younger in age.

Rhyolite Plug (C-Py)

The rhyolite plug of Mount Cooper has a youthful topographic form, which suggests that it may be younger than the Upper Carboniferous group of acid volcanics.

The steep-sided mount is a prominent local landmark, which rises some 700 feet above the surrounding granite. It is composed of multicoloured fluidal rhyolite and rhyolite breccia, which intrude the Ravenswood Granodiorite Complex. The plug was first described by Rands (1891), and Maclaren (1900) mapped the mountain as a volcanic focus or neck. It is circular in plan and is almost identical with Mount McConnell (just within the Bowen Sheet area) in shape and composition.

The age of Mount Cooper is unknown, but it is probably pre-Tertiary.

Granitic Stocks (C-Pg)

The characteristics of the unnamed late Palaeozoic granitic stocks are summarized in Table 6.

The Molybdenite Creek stock lies mainly within the Townsville Sheet area. In the Charters Towers Sheet area it forms high rugged country drained by Molybdenite Creek. The stock is a composite body: north of Molybdenite Creek it consists mainly of granodiorite, but grades into leucocratic microgranite; south of the creek a separate intrusion of pinkish grey medium-grained biotite adamellite appears to intrude the granodiorite (Fig. 9). The Molybdenite Creek stock intrudes the Ravenswood Granodiorite Complex.

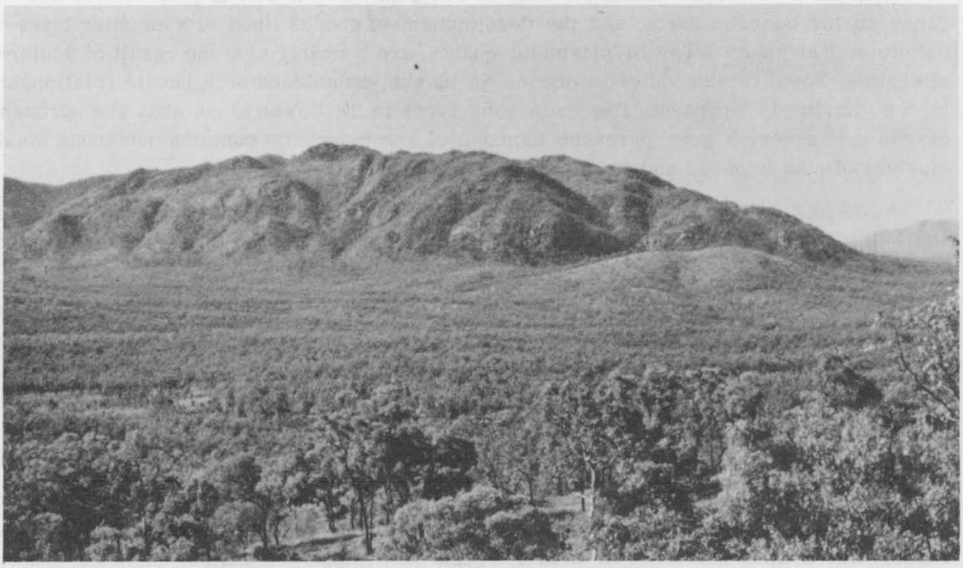

Fig. 9. Range formed by a stock of late Palaeozoic biotite adamellite 7 miles NE of Ravenswood. Roughly oval in plan, the stock is the youngest intrusion of a composite body drained by Molybdenite Creek. The stock intrudes the Ravenswood Granodiorite Complex, which forms the surrounding lower-lying country.

A stock 3 miles in diameter intrudes the Mount Windsor Volcanics and Ravenswood Granodiorite Complex in the headwaters of Fish Creek, in the Robey Range. It forms rugged hills which rise several hundred feet above the surrounding country. Only the northwestern margin of the stock was examined, where it consists of red and brown porphyritic biotite leucogranite. Flow-banded felsite dykes intrude the Mount Windsor Volcanics nearby.

A small stock of medium-grained biotite adamellite is located 1 mile south-southwest of Mount Canton, north of Stony Creek. The stock is semicircular in plan and its greatest length is along the southeastern margin, where it is faulted against volcanics (Cuv). The adamellite is cream to pale pink and contains small xenoliths of fine diorite which contains abundant small acicular crystals of hornblende. This acicular type of hornblende (usually green) occurs in other late Palaeozoic granitic bodies such as the Mundic Igneous Complex and the granite at Mount Stuart near Townsville. The stock intrudes the Ravenswood Granodiorite Complex.

TABLE 6: UNNAMED UPPER CARBONIFEROUS TO LOWER PERMIAN GRANITIC STOCKS (C-Pg)

Locality	Form	Lithology	Remarks
Molybdenite Creek	Irregular composite intrusion, including younger stock ($C-Pg_1$)	Granodiorite to leucogranite; younger stock is biotite adamellite	Intrudes Ravenswood Granodiorite Complex. Generally rugged country
Fish Creek	Circular stock	Red and brown porphyritic biotite leucogranite	Intrudes Mount Windsor Volcanics and Ravenswood Granodiorite Complex. Rugged country. Abundant associated rhyolite dykes
Stony Creek	Semicircular stock	Medium-grained biotite adamellite; dioritic xenoliths	Intrudes Ravenswood Granodiorite Complex. Partly bounded by faults. Low-lying country
Lulu Pocket	Circular stock	White and grey medium to coarse-grained granodiorite; abundant large xenoliths of fine to medium-grained granodiorite containing acicular hornblende	Intrudes granite mapped with late acid phase (0-Da) of Ravenswood Granodiorite Complex. Low-lying country
Mt Stone	Irregular intrusion, only partly unroofed	Hornblende-biotite grandiorite	Intrudes St Anns Formation and probably dolerite (C-Pi). Relationship to rhyolite (Cur) unknown. Low-lying country
St Annes Cross Range	Ovate stock	Biotite adamellite, granitic to micrographic texture; marginal zone of quartz-feldspar porphyry	Intrudes St Anns and Scartwater Formations and dolerite (C-Pi). Small offshoots of quartz-feldspar porphyry

Lulu Pocket, 16 miles south-southeast of Ravenswood, is a depression in the Robey Range, formed by a subcircular stock of white to grey, medium to coarse granodiorite, 2.5 miles in diameter. The stock intrudes granite mapped with the late acid phase of the Ravenswood Granodiorite Complex (O-Da), which forms the surrounding hills. The granodiorite contains numerous xenoliths of fine to medium-grained granodiorite containing abundant acicular hornblende.

The Mount Stone stock is a hornblende-biotite granodiorite which crops out in two places near Arthur Plains homestead in the southeastern part of the Sheet area. The outcrops apparently belong to a partly unroofed body which intrudes the St Anns Formation. An intrusive contact is exposed half a mile southeast of the homestead, where impure arenites have been metamorphosed to orthoclase-sericite-quartz hornfels containing a few poikiloblastic crystals of muscovite and chlorite. The age relations between this stock and the nearby intrusive rhyolite (Cur) and diorite (C-Di) are not known. The southwestern part of an oval stock of adamellite/granodiorite forms the St Annes Cross Range which rises 350 feet above the surrounding country. Elsewhere the stock has rather low relief. Two miles west-southwest of Arthur Plains homestead the intrusion consists of adamellite or granodiorite with a granitic to micrographic texture. It is composed of oligoclase (50%), potash feldspar (25%), quartz (20%), and red-brown biotite (5%). A narrow zone of quartz-feldspar porphyry occurs around the margin of the stock. Two small bodies of similar quartz-feldspar porphyry intrude the St Anns and Scartwater Formations nearby, and are probably offshoots of the stock. Rare marcasite coats joints and fractures in the St Anns Formation near a fault which displaces the eastern contact of the stock.

UPPER PERMIAN
(Table 5)

Betts Creek Beds

The Betts Creek Beds (Vine et al., 1964, unpubl.) consist of lithic sandstone, thick quartzose pebble and cobble conglomerate, siltstone (in places sandy or pebbly), mudstone, carbonaceous shale, coal, and minor tuff. The type area of the beds is near Pentland, in the Hughenden Sheet area. The Betts Creek Beds unconformably overlie the Cape River Beds and are in turn unconformably overlain by the Lower Triassic Warang Sandstone. A Glossopteris assemblage from the type locality and other exposures farther west indicates an Upper Permian age (White, 1964, unpubl.), which has been confirmed by palynological evidence (Evans, 1964, unpubl.).

The Betts Creek Beds extend into the Charters Towers Sheet area south of the Cape River to a point 3 miles southeast of Milray homestead, where they are overlain by Cainozoic sediments. The beds are poorly exposed and the only outcrops consist of isolated thick beds of lithic sandstone, commonly kaolinitic, in which devitrified glass is the main labile constituent. The arenites are mainly fine to very fine-grained, but some thin beds of quartzose pebble and cobble conglomerate are also present. Coarse siltstone and sandy siltstone, generally more quartzose than the arenites, and mudstone occur as rubble in creek beds. The mudstone is mainly blocky and only rarely micaceous and fissile. Some indeterminate plant materials is present in the finer sediments. The thickness of the Betts Creek Beds in the Charters Towers Sheet area is unknown, but it is probably similar to that in the type area (about 500 ft).

In the Hughenden Sheet area the coal seams and carbonaceous shale in the upper part of the Betts Creek Beds indicate a continental, probably swampy, environment. The grains in the arenites are little altered and mainly subangular to subrounded, which suggests that the source areas may have been nearby. Contemporary acid vulcanicity is indicated by the presence of tuff, and by the volcanic detritus in the sediments. These characteristics and the variations in the lithology suggest that the Betts Creek Beds were deposited in a non-marine environment. They are possibly outwash plain and piedmount deposits.

Mundic Igneous Complex
(new name)

The Mundic Igneous Complex comprises two granite stocks, volcanics, minor intrusives, and dykes. One stock crops out in the Charters Towers Sheet area, and the other in the Hughenden Sheet area. The stock in the Charters Towers Sheet area forms the Pentland Hills, a rugged and prominent range northwest of Homestead. In this range and its northern foothills the complex crops out over about 15 square miles. The complex is named after Mundic Creek, a tributary of the Campaspe River, which rises in the Pentland Hills.

In the south, the Pentland Hills rise abruptly about 1700 feet above the surrounding country, and the summit is 3000 feet above sea level. The northern and northeastern edges are not so steep.

Five main phases have been distinguished; the order of emplacement, distribution, and other characteristics are shown in Table 7, and their relationships in Figure 10.

Volcanics (Pum_1)

Volcanic breccia forms a narrow belt along the northern margin of the stock, and acid lavas crop out along the northeastern margin. The best outcrops are at the western end of the northern margin. The volcanic breccia has a greenish grey fine tuffaceous matrix, and contains fragments of granite from the Lolworth Igneous Complex, pieces of rhyolite, and broken grains of quartz and feldspar. The fragments range up to 60 cm across. Viewed from several miles to the southwest the breccia at the western end of the outcrop area appears to have a crude bedding which dips to the north at about 10^{o}, but no bedding has been seen in outcrop. Loose pieces of porphyritic dacite and rhyolite grading into microgranite occur on a steep smooth slope along the northeastern flank of the Pentland Hills. Some of the rocks here may be intrusive. A vertical intrusion of pink microgranite 100 feet thick, probably a ring dyke, separates them from the Cape River Beds to the east. To the southwest the microgranite passes into the leucogranite of the main Pentland Hills stock (Pum_3).

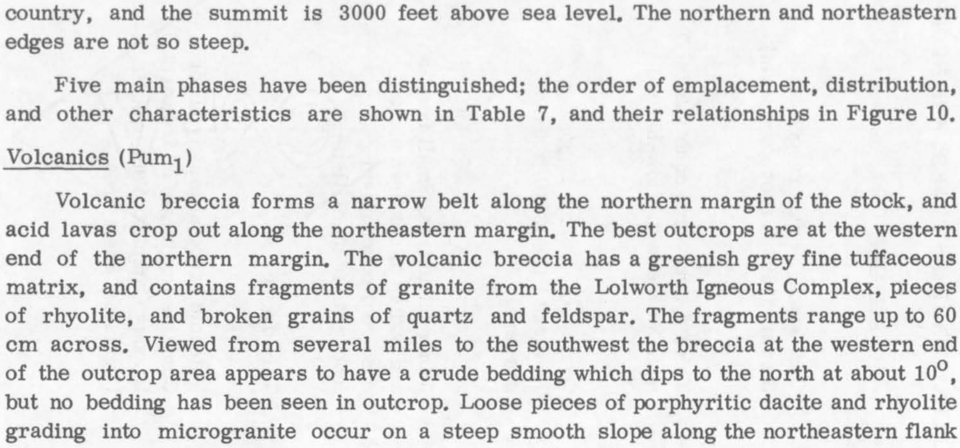

Fig. 10. Diagrammatic section, Mundic Igneous Complex, Charters Towers and Hughenden Sheet areas.

TABLE 7: SUMMARY OF MUNDIC IGNEOUS COMPLEX, CHARTERS TOWERS AND HUGHENDEN SHEET AREAS

Order of Emplacement	Map Symbol	Rock Types	Remarks	Distribution: Hughenden	Distribution: Charters Towers
5	(Pum_4)	Leucocratic microgranite	Oval stock. Forms rugged Mt Stewart (3300 ft above sea level)	X	-
4	(f)	Felsite (including rhyolite and other acid rocks)	Thick dykes. Some cone sheets(?) near Mt Stewart. Flow-banded	X	-
3	(Pum_3)	Drusy leucogranite	Oval stock. Forms rugged Pentland Hills (3040 ft above sea level)	-	X
2	(Pum_2)	Microgranite, microadamellite, micromonzonite, micro-diorite, diorite, dolerite	Minor intrusives. Small bosses and bodies of unknown shape. Also roof pendants on leucogranite stock (Pum_3)	X	X
	(d)	Dolerite, microdiorite	Thin dykes	X	X
1	(Pum_1)	Volcanic breccia; some dacite and rhyolite rubble on E slopes of Pentland Hills	Volcanic breccia crudely bedded. Contains fragments of Lolworth Igneous Complex. Vent breccia in Hughenden Sheet area	X	X

Minor Intrusives (Pum_2)

A very varied suite of fine-grained porphyritic holocrystalline rocks ranging from dolerite to microgranite forms a narrow belt between the volcanic breccia (Pum_1) and the main leucogranite stock (Pum_3), which intrudes them. A feature common to all the rocks is the presence of abundant plagioclase phenocrysts and fine acicular crystals of amphibole in the groundmass. Microadamellite with a similar texture appears to form a small boss southwest of Oaky Creek; another boss has been photo-interpreted to the north. Similar microadamellite forms roof pendants high up in the Pentland Hills. Fine-grained diorite with phenocrsyts of hornblende, but no acicular amphibole in the groundmass, forms the low northeastern shoulder of the Pentland Hills southwest of Oaky Yard. All occurrences mapped with the subunit Pum_2 are classed as minor intrusives, closely related to the main stocks of the complex. The porphyritic diorite southwest of Oaky Yard is the only minor intrusive which has not been deuterically altered.

In the narrow belt between the volcanic breccia and the leucogranite the rock types range from dolerite through microdiorite and micromonzonite to microadamellite and microgranite. The most common type is a porphyritic microadamellite which consists of zoned plagioclase phenocrysts set in a groundmass of red feldspar (probably orthoclase), acicular amphibole, quartz, and deuteric alteration products. The more basic rocks commonly occur as xenoliths in the more acid types. In texture and composition some of the rocks resemble those at the summit of Mount Stuart, near Townsville (Wyatt et al., 1969). The diorite which forms the low northeastern shoulder of the Pentland Hills contains conspicuous phenocrysts of hornblende up to 1 cm in diameter. Fine-grained biotite adamellite or granite occurs between the diorite and the leucogranite of the main stock. Southwest of Oaky Creek a high rugged ridge encircling a shallow depression is interpreted as a small boss intrusive into the Lolworth Igneous Complex. Boulders in a creek which drains this feature consist of pale pink porphyritic biotite-hornblende microadamellite, very similar to the commonest rock type in the main belt of minor intrusives. A similar depression with an encircling ridge occurs about a mile to the north.

Leucogranite (Pum_3)

The stock which forms most of the Pentland Hills is composed of medium-grained pink and red drusy leucogranite. The druses average 5 mm in diameter. The stock intrudes the minor intrusives along its northwestern margin. A marginal zone of porphyritic graphic microgranite occurs along the eastern margin above the smooth slope strewn with pieces of volcanics described above. The microgranite consists of microperthite (55%), quartz (25%), oligoclase (15%), and minor biotite. The stock is bisected by a sinistral wrench fault trending northwest, which has been the locus for felsite dyke intrusions.

Dykes

Felsite and dolerite/microdiorite dykes, forming two distinct suites, are genetically associated with the Mundic Igneous Complex. In the Charters Towers Sheet area the felsite dykes have not been found in contact with the more basic dykes, but in the Hughenden Sheet area the felsite suite is invariably the younger.

The swarms of felsite dykes, which are abundant in the Lolworth Igneous Complex north of the Pentland Hills, stand out as prominent ridges on the air-photographs. They also intrude the Cape River Beds east of the Pentland Hills.

Flow-banded leucocratic rhyolite is the commonest rock type. Some of the dykes contain phenocrysts of feldspar, and a few contain biotite. The dykes range from 5 to 50 feet wide and some can be traced for 3 to 4 miles on the air-photographs. Besides intruding the country rocks of the complex, felsite dykes have also been emplaced within the complex, parallel to the fault zone which bisects the Pentland Hills stock (Fig. 11).

The dolerite/microdiorite dykes cutting the Lolworth Igneous Complex 4 miles north of the Pentland Hills are parallel to a swarm of felsite dykes. The dykes average 2 to 3 feet wide, but their length is unknown as they have no topographic expression. They do not appear to be as abundant as the felsite dykes, but this may be because they are less conspicuous.

In the northwestern foothills of the Pentland Hills a dyke of altered prophyritic hornblende andesite intrudes the Lolworth Igneous Complex. The dyke contains rare rounded xenoliths of dolerite.

Age

The age of the Mundic Igneous Complex can only be established between wide limits; it intrudes the Cape River Beds (Cambro-Ordovician) and the Lolworth Igneous Complex (late Silurian or early Devonian), but antedates the Campaspe Beds (Pliocene ?). The complex may be coeval with rhyolite dykes which intrude probable Upper Permian sediments west of Pentland (Paine et al., 1965, unpubl., and in prep. b). Also, the Upper Permian Betts Creek Beds contain some contemporaneous volcanics. For these reasons the Mundic Igneous Complex is tentatively assigned to the Upper Permian.

Mineralization

No mineralization is known to be associated with the complex in the Charters Towers Sheet area, but gold and minor base metal deposits at the Lolworth diggings in the Hughenden Sheet area are possibly related to it.

Fig. 11. Contorted flow banding in a felsite dyke of the Mundic Igneous Complex, central valley of the Pentland Hills.

LOWER TRIASSIC
(Table 8)

Warang Sandstone

The Warang Sandstone (Vine et al., 1964, 1965, both unpubl.) crops out in scattered inliers in a tableland mantled by Quaternary sand southwest of the Cape River, and as an outlier which forms the Just Range near the centre of the Sheet area. The sandstone is well exposed in scarps and gorges in the inliers and in parts of the Just Range, but large areas are completely masked by sand.

The Warang Sandstone consists predominantly of white poorly sorted kaolinitic quartz sandstone with a few interbeds of red or white siltstone. The measured section (X22) in the valley of Crooked Creek (see map) is typical of the formation in the Sheet area, although it does not represent the total thickness present (Table 9).

A characteristic feature of the Warang Sandstone is the presence of large-scale trough cross-stratification. Although measurements in section X22 indicate an easterly current direction, too few observations were made to establish the general pattern.

Only part of the Warang Sandstone occurs within the Sheet area and nowhere is a complete sequence exposed. Near Pentland, in the Hughenden Sheet area, the formation is about 800 feet thick. Near Lake Buchanan to the south (Buchanan Sheet area) an incomplete section is at least 400 feet thick. In the Charters Towers Sheet area the sandstone is probably over 500 feet thick. It dips very gently to the southwest.

The Warang Sandstone rests with regional unconformity on the Upper Permian Betts Creek Beds. To the west and south of the Sheet area, it is overlain with regional unconformity by sandstone sequences of presumed Upper Jurassic age (Vine et al., 1964, unpubl.). No fossils have been found in the Warang Sandstone in the Charters Towers Sheet area, but Evans (1964, unpubl.) has identified spores of Lower Triassic age at Galah Gorge, about 30 miles northwest of Pentland in the Hughenden Sheet area.

The large-scale trough cross-stratification in the Warang Sandstone suggests that it was deposited in a fluviatile environment, possibly under torrential conditions. Deposition probably took place on extensive flood-plains. The presence of minor redbeds and the almost complete absence of organic remains also suggests an oxidizing environment. The source of the sandstone in the Charters Towers Sheet area was no doubt the granitic and metamorphic rocks in the western part of the Sheet area.

CAINOZOIC
(Table 8)

The Cainozoic era is represented mainly by lacustrine and fluviatile deposits. Small areas of olivine basalt are part of a large basalt plateau which lies to the northwest of the Sheet area (Twidale, 1956; White, 1962; Wyatt et al., 1969). A characteristic of the Cainozoic era is the widespread development of laterite and ferricrete.

TABLE 8: MESOZOIC TO CAINOZOIC STRATIGRAPHY

Age		Rock Unit	Lithology	References	Remarks
QUATERNARY		(Qa)	Sand, gravel, silt		Alluvium. Good water at shallow depth near larger watercourses
		(Qs)	Sand, silt, gravel		Mainly colluvial. Thickness up to 200 ft near Harvest Home homestead. Some possibly aeolian red sand in SW of area
		Toomba Basalt (Qt)	Vesicular olivine basalt	Wyatt et al. (1969); Paine et al. (1965, unpubl., and in prep. b); Rands (1891); Morton (1932a); Twidale (1956); White (1962)	Extreme NW corner of Sheet area. Eruption centre in Hughenden Sheet area. May be Recent in age. Broken surface impassable. Thickly vegetated but almost no soil. Overlies Nulla Basalt. Numerous permanent and temporary springs
	PLEISTOCENE	Sellheim Formation (Qe)	Semiconsolidated argillaceous sandstone, ferruginous sandstone, pebble conglomerate	Wyatt et al. (1969); Jack (1879); Howard (1959, unpubl.); Wyatt (1963, unpubl.)	High-level sediments of Burdekin River, forming low tablelands and terraces. Possibly partly lacustrine. 10-15 ft thick. Abundant silicified wood (<u>Pataloxylon</u> sp.). <u>Diprotodon</u> <u>australis</u> (Jack, 1879). Minor gold leads at Rishton. Probably essentially Pleistocene
		(Qg)	Semiconsolidated sand, gravel, and silt		Old high-level alluvial and outwash deposits. 30-40 ft maximum thickness. Some groundwater. Broadly equivalent to Sellheim Formation
		(Qo)	Grey and brown soils		Probably a relic of former calcareous lacustrine deposits
	PLIO-PLEISTOCENE	Nulla Basalt (Czn)	Olivine basalt	Wyatt et al. (1969); Paine et al. (1965, unpubl., and in prep. b); Twidale (1956); White (1962)	Plio-Pleistocene in age (A.W. Webb, pers. comm.). Thin in Charters Towers Sheet area; marginal to large basalt plateau to N. Rare sand lenses. Groundwater

Age		Rock Unit	Lithology	References	Remarks
TERTIARY		(Tf)	Nodular ferricrete; weathers to ironstone pebbles	Wyatt et al. (1969); Paine et al. (1965, unpubl., and in prep. b)	Part of weathering profile. Recognized only on Campaspe Beds; probably superimposed on laterite profile in places, but not readily recognized. Up to 4 ft thick
		Campaspe Beds (Tc)	Buff argillaceous sandstone; some conglomerate, siltstone, and claystone	Wyatt et al. (1969); Paine et al. (1965, unpubl., and in prep. b)	Underlies large part of Sheet area, but exposed only in creeks. Poorly sorted, weakly cemented piedmont deposit. Mostly derived from Lolworth Igneous Complex. Disconformably overlies laterite in Townsville Sheet area (Wyatt et al., 1969). Thickness 30-50 ft. Gold in deep lead near Pentland (Hughenden Sheet area)
		(Tl)	Laterite	Saint-Smith (1921); Wyatt et al. (1969)	Ferruginous, mottled, and pallid zones. Forms tablelands and mesas, but surface undulates. Formed on all older units. Overlain disconformably by Campaspe Beds at Red Falls in Townsville Sheet area
		(Tu)	Argillaceous sandstone, feldspathic sandstone, pebbly sandstone and conglomerate; minor siltstone and claystone. Locally silicified	Rands (1891); Morton (1945)	Mainly beneath laterite in tablelands and mesas. Probably lacustrine, with intermittent fluvial conditions. Up to 120 ft thick. Rare Eucalyptus sp. (Morton, 1945). Minor gold in leads at Little Red Bluff and Puzzler Walls. Probably pre-Miocene
	L. TRIASSIC	Warang Sandstone (Rlw)	White kaolinitic quartz sandstone; minor red and white siltstone	Vine et al. (1964, unpubl.); Evans (1964, unpubl.)	Probably fluvial; large-scale trough cross-bedding. Regionally unconformable on Betts Creek Beds. About 500 ft thick

TABLE 9: MEASURED SECTION OF WARANG SANDSTONE

(Section X22)

Thickness (ft)	
76	Kaolinitic quartz sandstone, brown to white, poorly sorted, mainly fine-grained but ranging to coarse-grained and gritty in bands and cross-strata; strong trough cross-stratification; friable except where case hardened; massive.
27	Mainly concealed (scattered poor exposures of kaolinitic quartz sandstone).
76	Kaolinitic quartz sandstone, white, poorly sorted, mainly fine-grained but grades into coarse-grained and gritty bands and cross-strata; strong trough cross-stratification with indicated current directions from 020^{o} to 190^{o}; massive, friable except where case hardened.
3	Quartz siltstone, red and white, blocky.
44	Kaolinitic quartz sandstone, white, poorly sorted, mainly fine-grained but grades into coarse-grained and gritty bands and cross-strata; strong trough cross-stratification with indicated current direction of 145^{o}; massive, friable except where case hardened.
2	Micaceous quartz siltstone, patchy red and white, thick-bedded.
10	Kaolinitic quartz sandstone, white, poorly sorted, mainly fine-grained, but grades into coarse-grained and gritty bands and cross-strata; strong trough cross-stratification with indicated current direction of 035^{o}.
Total 238	

TERTIARY

Sediments (Tu)

Flat-lying sandstone and conglomerate, probably of early Tertiary age, cover a large part of the southeast quarter of the Sheet area. The sediments originally formed a widespread sheet, which has been dissected into scattered mesas and plateaux. The sediments are best developed south of the Seventy Mile Range, but isolated outcrops occur north of the range in the Barrabas Scrub area, at the head of Scrubby Creek south of Rishton, at Little Red Bluff south of Charters Towers (Fig. 12), and at the Featherby Range southwest of Charters Towers.

In the most extensive area in The Tableland west of Cranbourne homestead, the sediments consist of coarse white to buff argillaceous sandstone, feldspathic sandstone, and argillaceous pebbly sandstone with lenses of pebble or cobble conglomerate. The beds have been strongly lateritized; the laterite cap has been stripped off most of The Tableland, but along its northwest edge 25 feet of ferruginous and mottled material have been preserved. The pebbles in the conglomerates are well rounded, but some of the quartz grains in the matrix are angular. Where the sandstone is strongly cross-bedded it is not normally argillaceous. In places, the beds immediately beneath the pallid zone of the laterite profile are partly silicified. Much of The Tableland is covered by deep red sandy soil, with rare pisolitic ferruginous concretions, which was probably derived from the eroded ferruginous capping.

Most of the laterite in the Seventy Mile Range is developed on sandstones similar to those described above, but it is also developed on older rocks. It has been possible to show only laterite on the map in this area because it masks the different patterns of the rock units on air-photographs. Between the Suttor and Cape Rivers the sequence consists of lateritized silicified quartz sandstone which forms cliffs up to 100 feet high. West of the Cape River the sandstone crops out as isolated mesas or low rises, and the thickness decreases westwards. Early Tertiary sandstone may underlie the Quaternary sand (Qs) in parts of the valleys of the Rollston River and its tributaries.

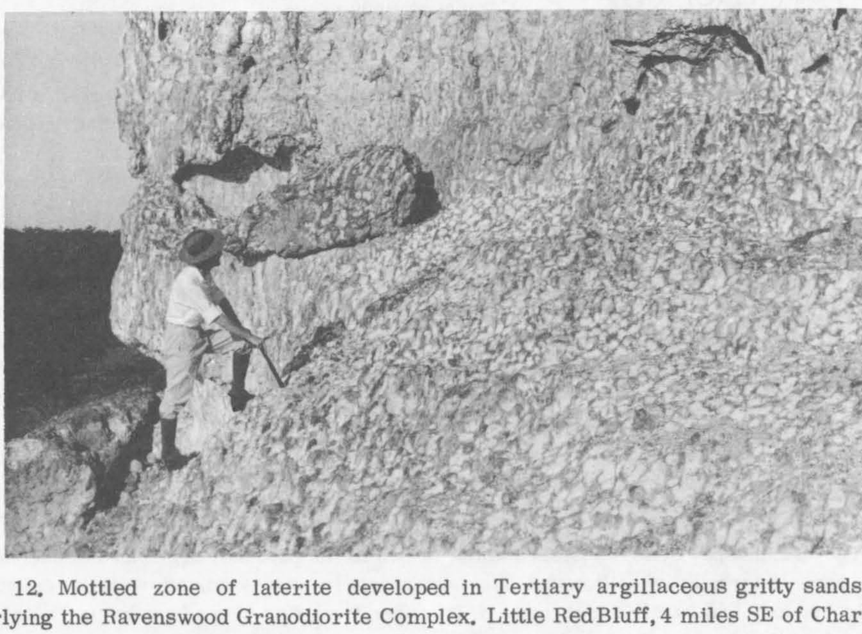

Fig. 12. Mottled zone of laterite developed in Tertiary argillaceous gritty sandstone overlying the Ravenswood Granodiorite Complex. Little Red Bluff, 4 miles SE of Charters Towers.

Morton (1945) has described the sequence at Little Red Bluff south of Charters Towers. Similar argillaceous and gritty sandstones crop out at the southern end of the Featherby Range near the Flinders Highway, and at The Bluff, 20 miles southeast of Charters Towers (Rands, 1891).

At Featherby Range there is probably no more than 40 feet of sediment. At Little Red Bluff Morton estimated a thickness of 100 feet, but on a ridge half a mile to the north the laterite is developed on granite and the sediments are absent. At the Bluff, Rands estimated a thickness of 120 feet. In the Seventy Mile Range and The Tableland the average thickness is about 60 feet, but it is much greater in places. Just west of the Suttor River the thickness is probably over 100 feet.

The sediments predate the period of major laterite development which is probably older than Miocene (N.F. Exon, pers. comm.). Morton (1945) collected dicotyledonous plant fossils from Little Red Bluff and the Featherby Range. Fossil dicotyledonous wood is abundant in the sediments 5 miles northwest of Cranbourne homestead. The wood cannot be identified, but a Cainozoic age is indicated (see Appendix 1). The wood is different from that found in the Sellheim Formation. The sediments are regarded as early Tertiary in age.

The sediments are lacustrine and fluvial deposits laid down on an uneven surface. The provenance of the sediments appears to have been local, as their composition is generally closely related to that of the underlying or nearby rocks. They were probably deposited during a period of peneplanation which immediately preceded the lateritization. Following lateritization the peneplain ws dissected and the products were laid down as a widespread deposit of sand and gravel, the Campaspe Beds.

Campaspe Beds

The Tertiary sediments between the Cape and Campaspe Rivers were mapped by Dunstan (1913) as the Campaspe-Cape Series. The present survey has shown that the sediments cover about 2500 square miles in the western part of the Sheet area, and that they extend into adjoining Sheet areas. This sedimentary unit was defined and named Campaspe Beds by Wyatt et al. (1969).

The Campaspe Beds, which are probably Pliocene, are extensively masked by a ferruginous capping and superficial sand. Their eastern limits have not been clearly established, but they probably thin out and disappear some 5 to 10 miles east of the Gregory Developmental Road. The Campaspe Beds mostly form extensive plains which are drained by the Cape and Campaspe Rivers and their tributaries. The larger creeks have cut channels 20 to 30 feet deep into the plains. To the north, towards the Grasstree Ranges and Seventy Mile Range, the beds form piedmont deposits at the foot of the higher country. The beds crop out well in the banks of most of the main creeks (Fig. 13).

The Campaspe Beds consist mainly of white to pale buff argillaceous sandstone with rare interbeds of siltstone. The sandstone is poorly sorted, weakly cemented, poorly bedded, and rarely cross-bedded. It ranges from fine to medium-grained, and the coarser portions tend to be pebbly.

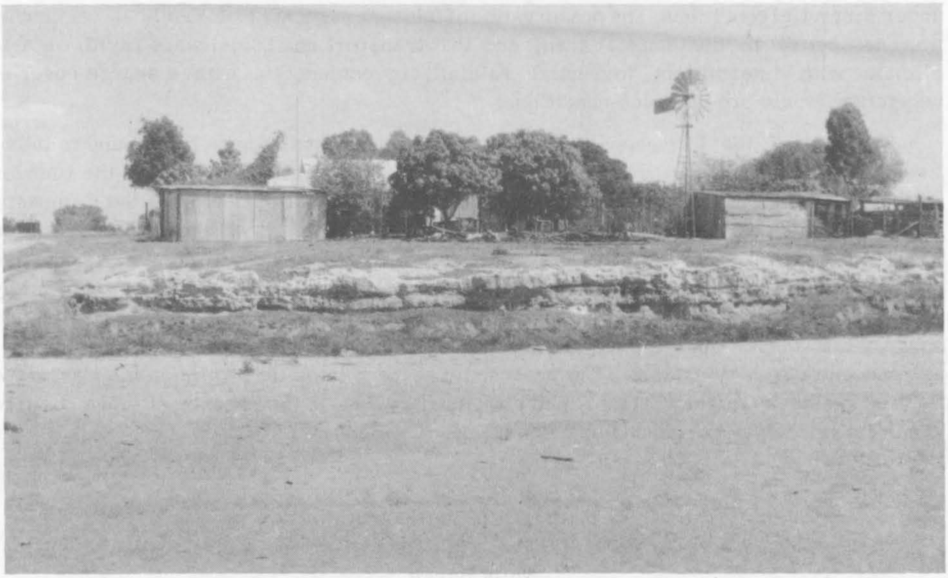

Fig. 13. Typical outcrop of the Campaspe Beds, where the Flinders Highway crosses Homestead Creek.

The sandstone is composed of quartz and feldspar in a matrix of fine quartz sand, silt, or clay. Rare flakes of randomly oriented muscovite, derived from the Lolworth Igneous Complex, are common. Small calcareous nodules occur in some of the fine-grained sandstone (e.g. at Rocky Bar homestead).

In interfluvial areas the Campaspe Beds are capped by a poorly preserved layer of nodular to pisolitic ferricrete which commonly weathers to buckshot gravel. The ferricrete generally forms a sharp step at the top of the uneven slope bordering the stream courses. The ferricrete has a maximum thickness of 3 to 4 feet. A zone of weak mottling underlies the ferricrete, commonly with an abrupt transition. The mottled zone is between 2 and 5 feet thick and passes down gradually into white or pale buff sandstone, which perhaps represents a pallid zone. In some areas, notably north of the Flinders Highway and west of Thalanga homestead, the ferricrete is absent, presumably owing to erosion.

In creek banks on the plains, well away from the source area, the maximum observed thickness is about 30 feet, but the base of the sequence is not exposed. Near the source area, where the base can be seen, the sequence is thicker. Up to 200 feet of sandy sediments have been encountered in water bores in the southwestern part of the Sheet area, but it is not known if they all belong to the Campaspe Beds.

The Campaspe Beds are a horizontal blanket deposit. There is a comparatively narrow zone with depositional dips of up to 10° around the source areas of the Grasstree Ranges and Seventy Mile Range. In the vicinity of Dillon Creek, the straight dark lines on the air-photographs were found to be scarp-like ridges, up to 10 feet high, of Campaspe Beds and ferricrete trending northwest and west; they are interpreted as normal faults of small displacement.

The source rocks of the Campaspe Beds have been chiefly granite (Lolworth Igneous Complex) and to a lesser extent metamorphics and volcanics (Mount Windsor Volcanics), older Tertiary sediments (Tu), and the Warang Sandstone. The marked absence of sorting and bedding, the random orientation of muscovite, and the persistence of the coarse fraction for long distances from the source all suggest that the beds were laid down under torrential conditions. The preservation of feldspar suggests that chemical weathering was not active in the source area, and that transport and burial were rapid. An arid climate with intermittent torrential rainfall, in conjunction with a sparse cover of vegetation, would provide such conditions.

The age of the Campaspe Beds is unknown. No fossils have been found in them. Even fossil wood, which occurs in the older Tertiary sediments (Tu) and the younger Sellheim Formation, is absent. At Red Falls in the Townsville Sheet area the Campaspe Beds disconformably overlie laterite (Wyatt et al., 1969). In the northern bank of Hann Creek, at the crossing 6 miles southeast of Myola homestead, white gritty sandstone of the Campaspe Beds, from which the ferricrete has presumably been removed by erosion, is overlain by the Nulla Basalt. Other exposures farther east in Hann Creek suggest that the Campaspe Beds and Nulla Basalt may in places abut against each other, as penecontemporaneous units. The presence of a type of lateritic profile on the Campaspe Beds suggests a Tertiary rather than a Quaternary age. In the absence of more positive evidence, their age is regarded as Pliocene.

UNDIVIDED CAINOZOIC

Nulla Basalt

The Nulla Basalt (Twidale, 1956) covers large areas in the Townsville, Hughenden, and Clarke River Sheet areas, and occupies 45 square miles in the northwest corner of the Charters Towers Sheet area.

The formation consists of blue-grey porphyritic olivine basalt, which is vesicular in places. The basalt is composed of abundant olivine phenocrysts, commonly altered to iddingsite, set in a groundmass of titanaugite and plagioclase. The basalt is generally weathered to red soil littered with rounded boulders. The best exposures are in creek banks. In the Hughenden Sheet area local residents report that water bores drilled in the basalt have intersected lenses of running sand.

The basalt is essentially horizontal. A low west-trending ridge of basalt boulders about 5 miles long can be seen on air-photographs just south of the Myola/Toomba track. The ridge has a maximum height of 5 feet and like similar ridges in the Campaspe Beds is probably a fault scarp. In the Charters Towers Sheet area the Nulla Basalt is probably less than 20 feet thick. The basalt is thicker along stream channels and probably thins out to only a few feet over interfluves. The Nulla Basalt was erupted from centres in the Hughenden and Clarke River Sheet areas, where the thickness is much greater.

Recent K/Ar whole rock isotopic age determinations, mainly on basalts from the Townsville Sheet, indicate five main eruptive episodes between 4.5 and 1 million years ago (Appendix 2), ranging from late Pliocene to Pleistocene.

QUATERNARY

Sellheim Formation

The Sellheim Formation was first noted by Jack (1879) and later named and mapped in the Townsville Sheet area (Wyatt, 1963, unpubl.; Wyatt et al., 1969).

The type area is in the Charters Towers Sheet area, south of Sellheim railway station. The sediment form low almost flat-topped rises bordered by low scarps. The rises occur discontinuously on both sides of the Burdekin River from Sellheim southeast to near The Twins. The boundary scarps are not as abrupt as those of the harder Tertiary sandstones.

The formation consists of poorly consolidated coarse argillaceous sandstone, ferruginous sandstone, and pebble conglomerate. Unconsolidated sand or weathered sandstone is predominant in the Rishton Scrub area. A maroon ferruginous sandstone, commonly pebbly, occurs near the base of the sequence.

The sediments are horizontal. Bedding is not conspicuous, but can be recognized in most outcrops. Cross-bedding is present in places, but is not common. The average thickness is 10 to 15 feet, but the formation is up to 30 feet thick in the south. The distribution suggests that the formation is an old high-level alluvial deposit of the Burdekin River.

The formation contains numerous fragments of fossil wood, and specimens from Rishton Scrub have been identified as Pataloxylon sp. (Appendix 1). Diprotodon australis recorded by Jack (1879) from sediments at Rishton, which are now mapped with the Sellheim Formation, indicates a Pleistocene age. The formation occurs at a lower topographic level than the Tertiary sandstones, and although mottled has no ferricrete on its upper surface. The mottling is associated with leaching adjacent to plant roots and was not apparently formed by lateritic processes. The formation is therefore regarded as younger than the periods of lateritization and ferruginization which affected the older Tertiary sediments and the Campaspe Beds. It may be as young as Pleistocene in age.

Sediments (Qg)

Three areas of semi-consolidated sediments cannot be correlated confidently with any of the other Cainozoic units, but are probably about the same age as the Sellheim Formation.

Southeast of Ravenswood, well bedded gravel, sand, and silt cap the interfluvial areas of the southern tributaries of Connolly Creek. The tops of the cappings are up to 40 feet above the bed of Connolly Creek. Along the southern margin of First Pocket, about 10 miles southeast of Ravenswood, a 4-foot bed of semi-consolidated conglomerate overlies up to 20 feet of coarse unsorted sand and silt. These sediments have a slight primary dip to the north. Remnants of a broad terrace border the Suttor River in the southeast. The remnants consist of unconsolidated, slightly ferruginous gravel, and are 30 to 40 feet above the river bed.

The sediments near Connolly Creek and in First Pocket are outwash deposits at the base of fault scarps, and the sediments along the Suttor River are old alluvial deposits.

Grey and Brown Soils (Qo)

Heavy-textured grey and brown soils cover several areas between Slogan Downs and Egera homesteads. The areas appear to lack rock outcrops, but calcareous nodules are common on the plain and in gullies. Nodules have also been encountered in water bores northeast of Old Victoria Downs homestead. This soil may have been developed on Cainozoic calcareous deposits which are no longer exposed.

Toomba Basalt

The Toomba Basalt (Twidale, 1956) covers an area of about 4 square miles in the extreme northwestern corner of the Sheet area. It occurs mainly in the Hughenden, Clarke River, and Townsville Sheet areas.

The Toomba Basalt is a porphyritic olivine basalt flow of very young aspect (Fig.14); its surface is extremely uneven, and it is an impassable barrier to traffic, its southern edge being known locally as the 'great basalt wall'. The only vent recognized lies in the Hughenden Sheet area about 25 miles west of Myola homestead.

The Toomba Basalt overlies the Nulla Basalt, and may be Recent in age.

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Superficial Sand (Qs)

Extensive low rises of clayey grit and coarse white or buff sand cover much of the catchment area of the Rollston River and Bligh and Kangaroo Creeks. The rises are noticeably higher than the recent stream alluvium. The sands and grits are outwash deposits resulting from the erosion of the Tertiary sediments and laterites on The Tableland and Seventy Mile Range.

The thickness of the sand varies greatly depending on the topography and amount of erosion of the underlying Tertiary sediments. Where it overlies partly eroded Tertiary sediments the thickness ranges from 10 to 20 feet. Two hundred feet of sandy material was encountered in a bore 4 miles north-northwest of Harvest Home homestead, but some of this could be Tertiary.

The sand is being dissected at the present day. It has been assigned a Quaternary age, but is regarded as older than the alluvium bordering the major streams.

In the southwest an extensive blanket of red sand, which overlies the lateritic profile developed on the Warang Sandstone, is also mapped with this unit. In Red Gorge Creek (just west of the Sheet area) it is at least 30 feet thick, but it is generally much thinner elsewhere.

Alluvium (Qa)

All the major streams are bordered by alluvial terraces composed mainly of sand and silt. The widest terraces border the braided stream channels of the Cape River in the southwest.

Generally there are at least two terraces along most streams, and the higher terraces are rarely covered by water except in the highest floods. Some of the deposits on the higher terraces may be Pleistocene in age.

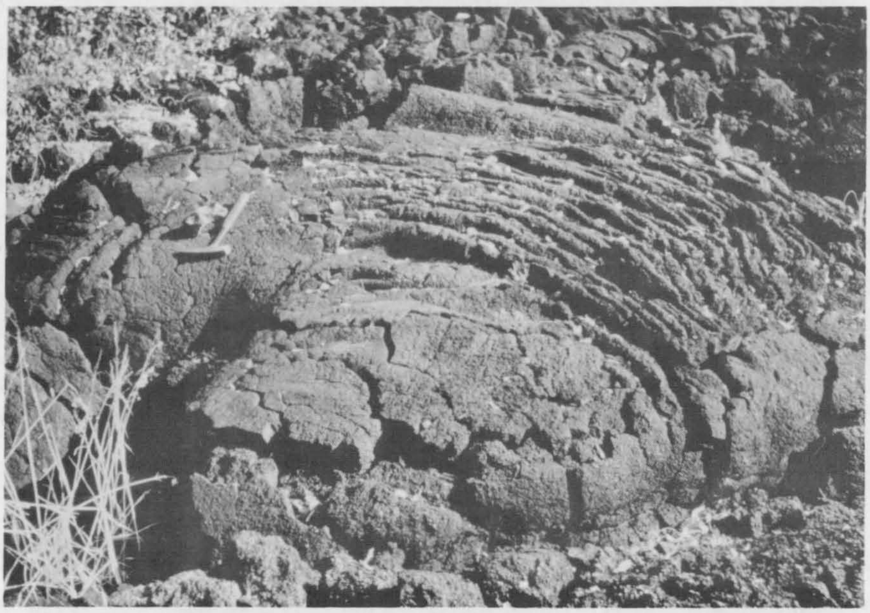

Fig. 14. Pahoehoe structures preserved on surface of Toomba Basalt (late Pleistocene or Recent) 0.3 miles NW of Myola homestead.

STRUCTURE
(Fig. 15)

Three major structural elements can be recognized in the Charters Towers Sheet area: the Lolworth-Ravenswood Block, the Drummond Basin, and the Galilee Basin.

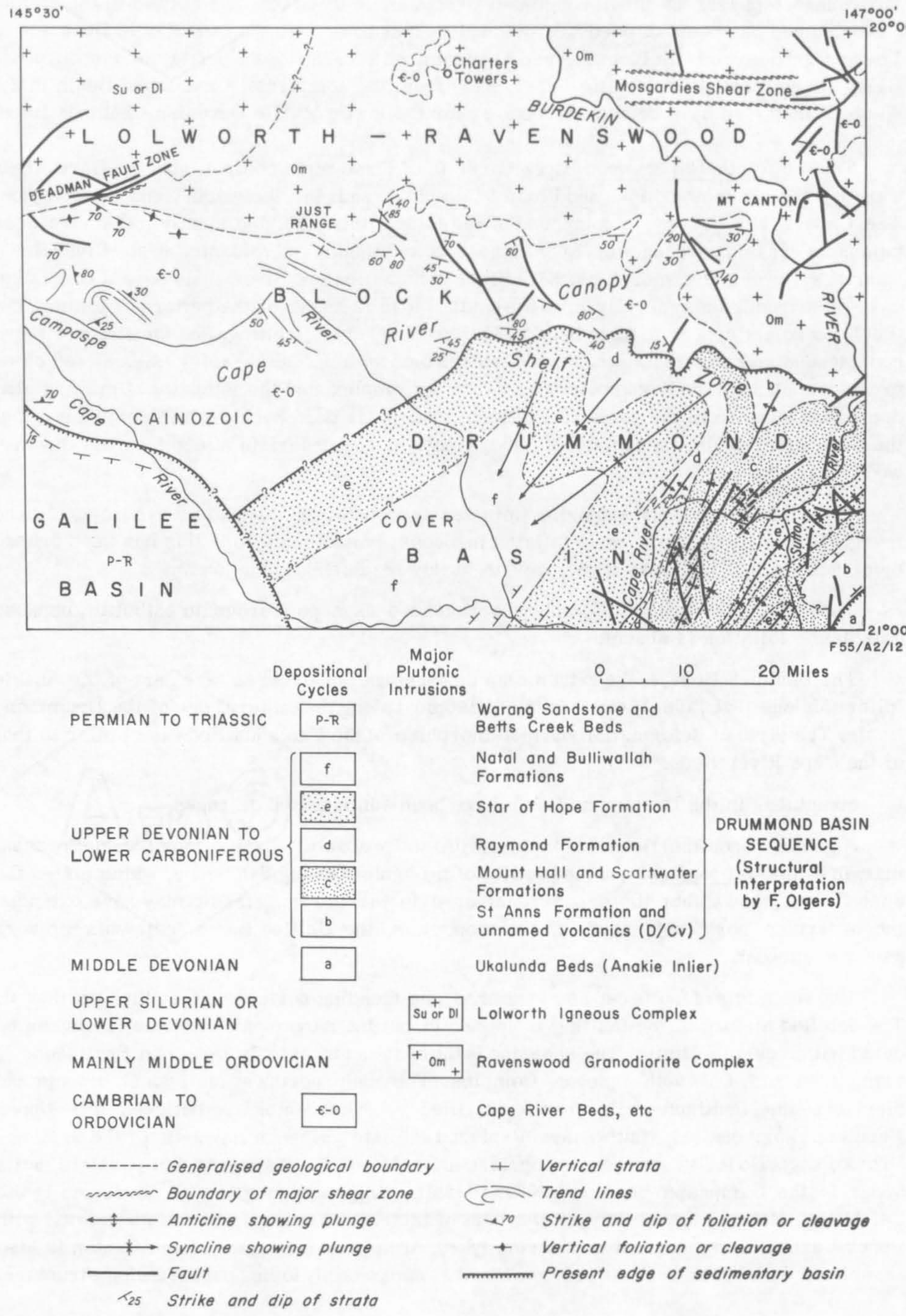

Fig. 15. Structural map.

The Lolworth-Ravenswood Block became stabilized in the late Silurian or early Devonian with the intrusion of the Lolworth Igneous Complex, the Barrabas Adamellite, and the youngest phases of the Ravenswood Granodiorite Complex. It emerged in the Middle Devonian and has been exposed to erosion since that time. In the upper Middle Devonian to Lower Carboniferous the block formed a source area separating the partly marine Burdekin Basin in the north (Townsville Sheet area) from the continental Drummond Basin in the south. It may also have been a source area for the lower Middle Devonian Ukalunda Beds.

The Lolworth-Ravenswood Block consists of three main components: the Cape River Canopy, the Ravenswood Granodiorite Complex, and the Lolworth Igneous Complex. The Cape River Canopy is composed of the folded, intruded, and locally metamorphosed remnants of a thick sequence of early Palaeozoic sediments and volcanics (Cape River Beds, Charters Towers Metamorphics, Kirk River Beds). The Cape River Beds have a consistent east-west trend, and generally dip to the south. Little is known of the pattern of folding, but the folds do not appear to have been tight. Shearing, close jointing, and faulting are more conspicuous and important structural features than folding. The shearing is localized close to the contact with the Ravenswood Granodiorite Complex, and the intensity of jointing also decreases away from the contact. The term 'canopy' is used because it is considered that the Cape River Beds and equivalents are in most places underlain at depth by the Ravenswood Granodiorite Complex.

The Ravenswood Granodiorite Complex is considered to be late synorogenic. The marginal zone of the complex is foliated in places; in some outcrops this has been caused by cataclasis, but in others it may be due to flowage during intrusion.

The Lolworth Igneous Complex is regarded as a post orogenic batholith, because cataclastic foliation is absent.

The Ukalunda Beds, in the extreme southeast corner of the area, are part of the Anakie Inlier (Malone et al., 1966), which formed basement along the eastern edge of the Drummond Basin. The style of deformation and metamorphism of the Ukalunda Beds is similar to that of the Cape River Beds.

Structures in the Drummond Basin have been summarized on pages

A gentle monoclinal flexure coincides with, and probably helped to localize, the present margin of the Galilee Basin, but the outlier of probable Warang Sandstone, which forms the Just Range, shows that the depositional area in the Lower Triassic may have extended much farther northeast. South of the monocline, the Galilee Basin sediments dip very gently southwest.

Two main sets of faults can be recognized, one trending northeast, the other northwest. The detailed history of the faulting is uncertain, but the movements on some faults can be dated within certain limits. The shearing in the east-northeasterly Deadman Fault Zone is older than the Lolworth Igneous Complex. The main northwst fault which bisects and displaces the Pentland Hills granite is filled by dykes which are believed to be Upper Permian. Northeasterly faults have displaced the late Palaeozoic granite of the St Annes Cross Range. No faults have been recognized in the Mesozoic sediments, but possible faults occur in the Campaspe Beds and Nulla Basalt. Ring fracturing is well developed in the Leichhardt Range immediately to the east of the Sheet area, where it is associated with Upper Carboniferous extrusives and ring dykes. An arcuate fault near Mount Canton is also associated with Upper Carboniferous volcanics, and possibly forms part of a ring structure.

The Mosgardies Shear Zone is a belt characterized by mylonitization, brecciation, and close jointing. Shearing is most intense along the northern margin of the Mosgardies Adamellite. The Mosgardies Shear Zone is parallel to the larger Alex Hill Shear Zone along the southern margin of the Townsville Sheet area.

GEOLOGICAL HISTORY

In the Cambrian and possibly Lower Ordovician a sequence of sediments and volcanics (Cape River Beds, Charters Towers Metamorphics, and Kirk River Beds) covered a large part of the Sheet area. In the Middle Ordovician the sequence was folded and intruded more or less contemporaneously by the Ravenswood Granodiorite Complex, a large batholith which now crops out over a larger area than the remnants of the rocks which it intruded. The emplacement of the complex was accompanied by varying degrees of dynamo-thermal metamorphism.

In the late Silurian or early Devonian, the Lolworth Igneous Complex was emplaced in the west, and the Barrabas Adamellite and the younger undelineated phases of the Ravenswood Granodiorite Complex in the east. Intrusion of these granites marked the final stage of an orogeny which stabilized the area as the Lolworth-Ravenswood Block.

In Middle Devonian time a new mobile zone developed along the southeastern side of the Lolworth-Ravenswood Block. The Ukalunda Beds, a thick series of marine sediments, were laid down in this mobile zone, of which a small part lies within the Charters Towers Sheet area. The Ukalunda Beds were uplifted and eroded, and possibly also intruded by granite at the end of the Middle Devonian. In the uppermost Devonian renewed downwarping in the mobile zone gave rise to the Drummond Basin, whose main development took place in the Lower Carboniferous. The Drummond Basin contains up to 25,000 feet of acid volcanics and sedimentary rocks, which were laid down in fluvial and lacustrine environments. The Drummond Group was folded, and possibly intruded by diorite (C-Pi), about the middle of the Carboniferous.

Hornblende porphyrite dykes were intruded at Charters Towers late in the Lower Carboniferous. In late Upper Carboniferous time the Lolworth-Ravenswood Block and the Drummond Basin were fractured. Some of the acid magma which rose up along the fractures was extruded as lavas and pyroclastics (Cuv), but some cooled below the surface as plugs (Cur) or as high-level granitic stokcs (C-Pg). Plutonism along the eastern edge of the Drummond Basin at this time may have caused further compression and folding in the basin (F. Olgers, pers. comm.). Subordinate freshwater sediments were deposited in lakes which were probably formed by the damming of the streams by lava flows. The cycle of igneous activity continued across the Carboniferous-Permian boundary. The rhyolite plug at Mount Cooper may be related to this phase of activity, or alternatively to a group of uppermost Permian rhyolite plugs in the Bowen Sheet area to the east.

The sequence in the Galilee Basin is continental throughout. Swampy conditions in the Upper Permian (Betts Creek Beds) were accompanied by vulcanism (Paine et al., 1965, unpubl., and in prep. b; Vine et al., 1964, unpubl.). The high-level igneous activity of the Mundic Igneous Complex probably took place at this time. Fluviatile sedimentation (Warang Sandstone) predominated in Lower Triassic time.

The Cainozoic geological history is summarized in Table 10.

ECONOMIC GEOLOGY

Gold and silver mineralization is widespread in the northern half of the area. Most of the mineralization appears to occur within or around the Ravenswood Granodiorite Complex, but minor occurrences are found within the Cape River Beds and Lolworth Igneous Complex. Two occurrences (Mount Leyshon and Mount Wright) are related to later volcanic foci.

Large quantities of gold and lesser amounts of silver have been produced from the Charters Towers Sheet area. No mining operations are currently being carried out, although the main producing centres, Charters Towers and Ravenswood, are once again attracting the attention of mineral exploration companies. The main producing years were from about 1880 to 1910. By 1916 practically all mining had ceased. There was a minor revival following the rise in the price of gold in 1931, but except for the Black Jack mine this activity was confined to small mines and prospects. Rising costs during and after the second world war curtailed this activity, and after the Black Jack mine finally closed in 1959, gold production virtually ceased. The last mines to produce ore in quantity were the Black Jack and the New Queen silver-lead mine at Liontown, which closed in 1962.

A full account of the economic geology of the Sheet area is being prepared by K.R. Levingston, District Geologist at Charters Towers.

TABLE 10: CAINOZOIC GEOLOGICAL HISTORY

	Epoch	Sedimentation	Fossils	Volcanic activity	Tectonics	Remarks
QUATERNARY	Recent	River alluvium (Qa); Superficial outwash sand (Qs); Grey and brown soils (Qo)		Toomba basalt	?	
	Pleistocene	Semi-consolidated alluvial and outwash deposits (Qg) Sellheim Formation	(?)*Diprotodon australis* *Pataloxylon sp*	Nulla basalt	Renewed uplift; Uplift with faulting	Rejuvenation of drainage, renewed dissection; Lacustrine and high-level alluvial deposition; Period of degradation
TERTIARY	Pliocene	Campaspe Beds				Ferricrete development; Deposition
	Miocene					Dissection of laterite surface
	Oligocene	Unnamed sediments in the southeast and at Featherby Range (Tu)	Dicotyledonous plants, angiosperm wood		Stable	Major lateritization; Peneplanation; lacustrine, piedmont, and fluviatile deposition
	Eocene					
	Palaeocene					

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Gold

By far the most important mining centre in the area was Charters Towers - the principal centre of the Charters Towers Gold and Mineral Field. Although production from Charters Towers has been small since the 1920's, its total recorded production since its discovery in 1871 to the end of 1964, except for a small quantity from the Cape River area, was 6,805,510 fine ounces of gold, and until 1959 it had produced more gold than any other mining centre in Queensland. Up to 1916, when practically all mining ceased, 1,000,565 ounces of silver and 3684 tons of lead were also recovered (Blatchford, 1953).

The geology of the Charters Towers field has been described by Reid (1917). All the important mines were located in the Ravenswood Granodiorite Complex. The lodes are simple or composite tabular bodies, wholly or partly within fissures. The fissures belong to two sets of faults which dip to the east-northeast at 27° to 36°, and to the north or northwest at 23° to 50°. The fissure walls are well defined and are commonly slickensided. The lodes are formed of one or more quartz veins separated by crushed and altered country rock. In the major fissures two or more separate veins may occur in parallel or branching channels. Some of them are separated by unaltered country rock and were mined as independent bodies as in the Day Dawn and Brilliant systems.

The ore shoots were irregular in shape and no consistent direction of pitch is apparent. A crude en echelon arrangement of the shoots in parallel veins is discernible in places.

The deepest workings were on the Brilliant lode (3000 ft) and on the Day Dawn lode (2700 ft). Only a few of the other lodes were worked below 1000 feet. In all cases values became poorer with depth.

The ore is a simple mesothermal mineral essemblage: the normal primary constituents, in addition to native gold, are quartz, pyrite, galena, and sphalerite. The less common minerals include calcite, chalcopyrite, gypsum, barite, arsenopyrite, native arsenic, and an unidentified telluride. Galena was important as an indicator of gold values.

The localization of the ore does not appear to have been related to the country rock or to intersection of the lodes either by dykes, early barren quartz veins, or faults (except in the last case for minor local enrichment).

The other important mining centre was Ravenswood, on the Ravenswood Gold and Mineral Field. This also was one of the major gold-producing areas of Queensland, the total yield to the end of 1963 being some 900,000 fine ounces. The field was discovered in 1868, but early development was slow and it was not until between 1898 and 1912 that annual production was consistently high and more than half the total yield was produced.

The main lodes, comprising quartz-sulphide orebodies in fissures in the Ravenswood Granodiorite Complex, were situated in the town area and at Sandy Creek. The Ravenswood field included a number of outside centres, each of which had its own village, around which were grouped several mines. Except perhaps for Brookville, none of these centres was a large producer. They include Kirk, Four Mile, Donnybrook, One Mile (or Totley, mainly silver), Trieste, and Hillsborough (or Eight Mile).

The lodes at Ravenswood itself trend in two principal directions: some trend between north-northwest and north-northeast and dip to the east, and others between northeast and east and dip to the south. The north-trending lodes are more important and numerous. The lodes do not form a network, but rather several groups of north-trending lodes are separated from each other by a few east-trending lodes.

At Sandy Creek, a few miles southeast of Ravenswood, the lodes again trend in two directions. The more important lodes dip southwest, the less important northwest.

In many of the outlying centres the lodes generally have a north to northwesterly or an east to east-northeasterly trend.

Payable ore was obtained to a depth of 700 feet, but only a few of the many lodes were worked below 400 feet. The highly refractory sulphide ores were not amenable to normal battery treatment and this retarded early development. The primary minerals included native gold, galena, chalcopyrite, sphalerite, pyrite, quartz, and possibly calcite.

The various mines on the field have been described by Maclaren (1900), Cameron (1901, 1903), and Reid (1934).

Other gold occurrences in the Ravenswood Granodiorite Complex occur southeast, south, and southwest of Charters Towers. None was a big producer, but among the more important were Broughton, Rishton, Dreghorn, St Pauls, Lighthouse, Windsor, and Southern Cross. Many are described by Marks (1913).

A little gold has been produced from the Old Homestead diggings, 7 to 12 miles north of Homestead (Rands, 1891) and from the Big Hit mine (Morton, 1939a, b). In both cases the mineralization is probably related to the Lolworth Igneous Complex.

Gold has also been found in the Cape River Beds and Mount Windsor Volcanics: gold was worked at the New Homestead diggings southeast of Thalanga siding late last century (Rands, 1891); at Liontown in the early 1900's (Morton, 1937); and at the Highway mine in the 1950's (Connah, 1960). Numerous old shallow workings, about which little is known, occur between Brittania homestead and the Gregory Developmental Road. They are the result of gold mining and prospecting activities earlier this century; some may be the result of work during the depression years of the 1930's. None of the deposits in the Cape River Beds has been a large producer.

Gold has been mined in volcanic rocks which postdate the Ravenswood Granodiorite Complex at Mount Leyshon (Jack, 1885; Rands, 1891; Morton, 1932b) and Mount Wright (Morton, 1928, unpubl.; Connah, 1956). At Mount Leyshon the gold occurs in rhyolite and dacite agglomerate (Pzo) in an old volcanic vent at the contact between the Ravenswood Granodiorite Complex and the Cape River Beds. The gold is disseminated throughout the rock, or occurs in association with thin limonite veins and stringers which permeats the country rock. Values are erratic. Other primary minerals include pyrite and chalcopyrite. Production from 1887 to 1946 was about 38,000 fine ounces of gold from about 208,000 tons of ore. At Mount Wright deposits occur in a hydrothermally altered breccia pipe (Cur). The breccia consists mainly of biotite granite, but it also contains pieces of fine-grained volcanics or dyke rocks. The lode consists of an ill defined zone irregularly impregnated with pyrite and sphalerite, with traces of copper and arsenic. Siderite also occurs in both auriferous and non-auriferous sections. Production figures are incomplete, but approximately 1300 fine ounces of gold were produced.

Small quantities of gold have also been worked from deep leads at the base of Tertiary sediments forming Little Red Bluff (Morton, 1945), and the Puzzler Walls.

Silver-Lead

Apart from Charters Towers, only two areas have been important silver-lead producers: the Totley area (Kings) near Ravenswood (Connah, 1953; Levingston, 1969), and the Liontown area (Levingston, 1952, 1956, 1960, 1963).

At Totley the main lode is Kings. It consists of altered and crushed granitic material in a reddish medium-grained quartz diorite or tonalite of the Ravenswood Granodiorite Complex. The lode dips northeast at 30^{o} to 35^{o} in the shallower workings, but steepens to 50^{o} to 60^{o} in the deeper workings. The footwall is well defined and slickensided, but the hangingwall is generally poorly defined. The lode ranges from a few inches to 25 feet wide. Two main shoots were worked and these are possibly related to the change in dip of the lode. The ore occurs as stringers, bands, or lenses of massive sulphides in the altered quartz diorite. High silver values are associated with the wider galena veins, which were rich in tetrahedrite. Other minerals recorded are pyrite, sphalerite, arsenopyrite, pyrargyrite, chalcopyrite, proustite, argentite, stephanite, a little gold, and a lead-antimony sulphide. Although several attempts have been made to reopen the mine, it virtually ceased operations in 1891. Production figures are scant, but to 1891 ore and concentrate to the value of 112,000 pounds had been raised.

At Liontown the deposits occur in sheared volcanics and sediments of the Cape River Beds, which are intruded by acid porphyries which are probably apophyses of the Ravenswood Granodiorite Complex. The schistosity trends east-northeast and dips steeply north and south. The bedding is not readily recognizable. The lodes consist of veins of cerussite, limonite, quartz, and kaolin in sheared country rock. Lead also occurs in schistose material outside the veins as well as in a white gouge commonly present alongside the veins. The width of the lode ranged from 8 to 24 inches. Deposition was probably controlled principally by two series of fractures, both striking at 080^{o}, one dipping 60^{o} south and the other vertically. The lodes were discovered in 1951 and were worked mainly from the Liontown and New Queen mines. Work ceased at the end of 1961 because of the lack of a suitable market for the ore. The workings have not reached the primary ore, which was intersected by subsequent diamond drilling (Levingston, 1963). The secondary ores have not been worked out, so that the deposits still have potential for small-scale mining operations. Production from 1951 to the end of 1961 was about 52υ tons of lead, 3000 fine ounces of gold, and 54,000 fine ounces of silver.

Copper, Molybdenum, and Antimony

Copper was mined at the Carrington mine, Liontown, between 1905 and 1911, but production was very small. This was the only mine in the Sheet area that could be regarded essentially as a copper producer, although its gold production was probably of equal importance. Some copper is recorded from other mines at Charters Towers and Ravenswood, but it can only be regarded as a by-product of small parcels of smelted ore which were shipped to treatment works outside the fields. Small copper deposits occur in the St Pauls area, but production was very small.

At Liontown, the Carrington deposit occurs in schists of the Cape River Beds. The lode channel is marked by fairly prominent walls, and is conformable with the schists. The lode consists of varying proportions of sulphide ore and country rock. The ore is a compact intimate mixture of silica, pyrite, and chalcopyrite; the country rock has been crushed and silicified and mineralized to varying degrees. Barite also occurs as a gangue mineral. Gold values appear to have been erratic. Samples from No.6 level of the Carrington P.C. mine average 6 to 7 percent copper and 4 to 5 cwt of gold per ton (Morton, 1937).

The mine ceased operations about 1911, but the No. 2W shaft was reopened in 1956 (Levingston, 1960) to investigate a lead prospect found nearby. Trial parcels containing gold, lead, copper, and zinc showed that the ore would be difficult to treat, and, as reserves were not known, the lessees lost interest.

Geochemical and geophysical surveys and diamond drilling were recently carried out at the Titov copper prospect and at Keans molybdenite prospect, near Ravenswood (Lissiman et al., 1965; Clarke, 1969, unpubl.). Only low values were indicated, and there has been no production, although these occurrences are a hopeful sign that the area may have potential for economic mineralization of the porphyry copper type.

Stibnite occurs in the Cape River Beds at a small prospect known as The Antler, 3 miles northwest of Homestead. No production is recorded.

Crushed Rock

The large mine dumps at Charters Towers provide a ready source of rock for crushing. Large quantities have been used as railway ballast, road construction material, and aggregate for concrete.

Water

Many shallow bores have been put down in a wide variety of rock types. Considerable quantities of groundwater are available from alluvium and weathered granite. The Campaspe Beds are worthy of investigation as a large potential source of groundwater at shallow depth.

Minor Mineral Occurrences

Pebbles of barite occur in a creek at the southeastern end of a low range which extends southeast from Thalanga siding.

A vein of magnesite 8 cm thick and a vein of sphalerite 3 mm thick were found in metavolcanics of the Cape River Beds in the main railway cutting through the low range at Thalanga siding.

Small quantities of pyrite and magnetite are concentrated in thin bands in metavolcanics of the Cape River Beds 4 miles west of Thalanga siding.

REFERENCES

BLATCHFORD, A., 1953 - Charters Towers goldfield; in GEOLOGY OF AUSTRALIAN ORE DEPOSITS. 5th Comm. Min. Metall. Cong., 1, 796-806.

BRYAN, W.H., 1926 - Earth movements in Queensland. Proc. Roy. Soc. Qld, 37, 1-82.

CAMERON, W.E., 1901 - Ravenswood goldfield. Qld Govt Min. J., 2, 16-19.

CAMERON, W.E., 1903 - Recent mining developments on the Ravenswood goldfield. Ibid., 4, 184-8.

CASEY, D.J., 1969 - Tangorin, Qld - 1:250,000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes SF/55-5.

CLARKE, D.E., 1969 - The geology of the Ravenswood 1-mile Sheet area, Queensland. Bur. Miner. Resour. Aust. Rec. 1969/117 (unpubl.).

CLARKE, D.E., PAINE, A.G.L., and JENSEN, A.R., in press - Geology of the Proserpine 1:250,000 Sheet area, Queensland. Bur. Miner. Resour. Aust. Rep. 144.

CLARKE, D.E., and PAINE, A.G.L., 1970 - Charters Towers, Qld - 1:250,000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes SF/55-2.

CONNAH, T.H., 1953 - Totley (King's) silver mine, Ravenswood. Qld Govt Min. J., 54, 171-6.

CONNAH, T.H., 1956 - Mount Wright gold deposits, Ravenswood: diamond drill exploration. Ibid., 57, 528-35.

CONNAH, T.H., 1960 - Gold workings: 'The Highway' lease, Charters Towers. Ibid., 61, 461-3.

CONNOLLY, H.J., 1935 - Gold mines of Australia concession area, Charters Towers. Geol. Surv. Qld Auth. Rep. 499 (unpubl.).

DAINTREE, R., 1870 - On the Ravenswood, Mount Wyatt, Cape River goldfields, etc. Notes Proc. Leg. Ass. Qld.

DUNSTAN, B., 1913 - Queensland mineral index. Geol. Surv. Qld Publ. 241.

EVANS, P.R., 1964 - Some palynological observations on samples from the north-eastern Eromanga Basin, central Queensland. Bur. Miner. Resour. Aust. Rec. 1964/76 (unpubl.).

GIBB, R.A., 1968 - North Eromanga and Drummond Basins gravity surveys, Queensland, 1959-63. Bur. Miner. Resour. Aust. Rep. 131.

GREGORY, C.M., 1969 - Ayr, Qld - 1:250,000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes SE/55-15.

HARLAND, W.B., SMITH, A.G., and WILCOCK, B., 1964 - The Phanerozoic time scale. Quart. J. geol. Soc. Lond. (Supplement), 120s.

2/70—7

HILL, Dorothy (Ed.), 1953 - Geological map of Queensland (at a scale of 40 miles to 1 inch). Qld Dept Mines.

HILL, Dorothy, and DENMEAD, A.K., 1960 - The geology of Queensland. J. geol. Soc. Aust., 7.

HILL, Dorothy, PLAYFORD, G., and WOODS, J.T. (eds), 1967 - Devonian fossils of Queensland. Qld Palaeontogr. Soc. Dd32.

HILL, Dorothy, and JELL, J.S., 1969 - Devonian corals from Ukalunda. Geol. Surv. Qld Publ. 340.

HOWARD, P.F., 1959 - Report on A. to P. 140M, Charters Towers, Queensland. Geol. Surv. Qld Auth. Rep. 369 (unpubl.).

JACK, R.L., 1879 - On the geology and mineral resources of the district between Charters Towers goldfield and the coast. Geol. Surv. Qld Publ.1.

JACK, R.L., 1885 - Report on the gold deposits of Mount Leyshon. Ibid., 18.

JACK, R.L., 1886 - Geological map of Queensland on the scale of 32 miles to an inch. Ibid., 30.

JACK, R.L., and ETHERIDGE, R., 1892 - THE GEOLOGY AND PALAEONTOLOGY OF QUEENSLAND AND NEW GUINEA. London, Dulau. Also Geol. Surv. Qld Publ. 92.

JACK, R.L., RANDS, W.H., and MAITLAND, 1892 - Geological map of Charters Towers goldfield, on the scale of 4 chains to an inch. Ibid., 95.

JACK, R.L., RANDS, W.H., and MAITLAND, A.G., 1898 - Geological map of the Charters Towers goldfield, showing underground workings, on the scale of 4 chains to an inch. Ibid., 142.

LEICHHARDT, L., 1847 - JOURNAL OF AN OVERLAND EXPEDITION IN AUSTRALIA. London, Boone.

LEVINGSTON, K.R., 1952 - Silver-lead discovery, Liontown area. Qld Govt Min. J., 53, 492-3.

LEVINGSTON, K.R., 1956 - Silver-lead workings, Liontown. Ibid., 57, 57-60.

LEVINGSTON, K.R., 1960 - Carrington's No. 2W Shaft, Liontown. Ibid., 61, 161-2.

LEVINGSTON, K.R., 1963 - Department diamond drilling, Liontown. Ibid., 64, 533-9.

LEVINGSTON, K.R., 1969 - Great Extended silver mine, Ravenswood. Ibid., 76, 248-9.

LISSIMAN, J.C., BAKER, W.E., and MARSHALL, N.J., 1965 - Geochemical prospecting by North Broken Hill Limited, with special reference to molybdenum; in EXPLORATION AND MINING GEOLOGY. 8th Comm. Min. metall. Cong., 2, 90-5.

MACLAREN, J.M., 1900 - Report on the geology and reefs of the Ravenswood geolfield. Geol. Surv. Qld Publ. 152.

MAITLAND, A.G., 1893 - Charters Towers goldfield; in Annual progress report of the Geological Survey for the year 1892. Ibid., 94, 10-11.

MALONE, E.J., 1969 - Mount Coolon, Qld - 1:250,000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes SF/55-7.

MALONE, E.J., JENSEN, A.R., GREGORY, C.M., and FORBES, V.R., 1966 - Geology of the southern half of the Bowen 1:250,000 Sheet area, Queensland. Bur. Miner. Resour. Aust. Rep. 100.

MARKS, E.O. 1912 - Notes on portion of the Burdekin Valley. Proc. Roy. Soc. Qld, 24, 93-102.

MARKS, E.O., 1913 - Outside mines of the Charters Towers goldfield. Geol. Surv. Qld Publ. 238.

MORTON, C.C., 1928 - The Mother Lode, Mount Wright, Ravenswood goldfield. Rep. geol. Surv. Qld (unpubl.).

MORTON, C.C., 1932a - Gold mining at Lolworth Creek. Qld Govt Min. J., 33, 295-7, 334-6.

MORTON, C.C., 1932b - Mount Leyshon, Charters Towers district. Ibid., 33, 225-7.

MORTON, C.C., 1937 - Carrington P.C. mine, Liontown. Ibid., 38, 198-9.

MORTON, C.C., 1939a - Gold discovery near Fern Springs, Charters Towers goldfield. Ibid., 40, 90-1.

MORTON, C.C., 1939b - Fern Springs, Charters Towers. Ibid., 40, 294-5.

MORTON, C.C., 1945 - Little Red Bluff, Charters Towers. Ibid., 46, 234.

MURRAY, W., and HARTLY, J.S., 1960 - Mount Leyshon. Rep. to Mount Isa Mines Ltd (unpubl.).

OLGERS, F., in prep. - Geology of the Drummond Basin, Queensland. Bur. Miner. Resour. Aust. Bull. 132.

OLGERS, F., 1969 - Buchanan, Qld - 1:250,000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes SF/55-6.

OLGERS, F., DOUTCH, H.F., and EFTEKHARNEZHAD, J., 1967 - Progress report on the geology of the Drummond Basin, Queensland. Parts I and II. Bur. Miner. Resour. Aust. Rec. 1967/153 (unpubl.).

PAINE, A.G.L., in prep. - Bowen, Qld - 1:250,000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes SF/55-3.

PAINE, A.G.L., CLARKE, D.E., and GREGORY, C.M., in prep. a - Geology of the northern half of the Bowen 1:250,000 Sheet area, Queensland (with additions to the geology of the southern half). Bur. Miner. Resour. Aust. Rec. (unpubl.).

PAINE, A.G.L., GREGORY, C.M., and CLARKE, E.D., 1969 - Geology of the Ayr 1:250,000 Sheet area, Queensland. Bur. Miner. Resour. Aust. Rep. 128.

PAINE, A.G.L., HARDING, R.R., and CLARKE, D.E., 1965 - The geology of the north-eastern part of the Hughenden 1:250,000 Sheet area, north Queensland. Bur. Miner. Resour. Aust. Rec. 1965/93 (unpubl.).

PAINE, A.G.L., HARDING, R.R., and CLARKE, D.E., in prep. b - Idem. Bur. Miner. Resour. Aust. Rep. 126.

RANDS, W.H., 1891 - Cape River goldfield. Geol. Surv. Qld Publ. 73.

RANDS, W.H., 1893 - Charters Towers goldfield; in Annual Progress Report of the Geological Survey for the year 1892. Ibid., 94, 8-9.

REID, J.H., 1917 - The Charters Towers goldfield. Geol. Surv. Qld. Publ. 256.

REID, J.H., 1818 - Geological map of Charters Towers and environs. Ibid., 244.

REID, J.H., 1930 - The Queensland Upper Palaeozoic succession. Ibid., 278.

REID, J.H., 1934 - Some Ravenswood mines. Qld Govt Min. J., 35, 77-8.

RICHARDS, J.R., WHITE, D.A., WEBB, A.W., and BRANCH, C.D., 1966 - Isotopic ages of acid igneous rocks in the Cairns Hinterland, north Queensland. Bur. Miner. Resour. Aust. Bull. 88.

SAINT-SMITH, E.C., 1921 - Lateritic deposits near Charters Towers. Ibid., 22, 359-60.

TENISON WOODS, J.E., 1883 - A fossil plant formation in central Queensland. J. Roy. Soc. N.S.W., 16, 179-92.

TUCKER, R.M., 1962 - Specimens from the Mabel Jane mine, Charters Towers. Petrological report. Rep. Geol. Surv. Qld (unpubl., 23/3/1962).

TURNER, F.J., and VERHOOGEN, J., 1960 - IGNEOUS AND METAMORPHIC PETROLOGY. N.Y., McGraw Hill, 2nd ed.

TWIDALE, C.R., 1956 - A physiographic reconnaissance of some volcanic provinces in north Queensland, Australia. Bull. Volc., 2(18), 3-23.

VINE, R.R., CASEY, D.J., and JOHNSON, N.E.A., 1964 - Progress report, 1963, on the geology of the northeastern Eromanga Basin, Queensland. Bur. Miner. Resour. Aust. Rec., 1964/39 (unpubl.).

VINE, R.R., JAUNCEY, W., CASEY, D.J., and GALLOWAY, M.C., 1965 - Geology of the Longreach-Jericho-Lake Buchanan area. Ibid., 1965/245 (unpubl.).

VINE, R.R., and PAINE, A.G.L., in prep. - Hughenden, Qld - 1:250,000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes SF/55-1.

WEBB, A.W., 1969 - Metallogenic epochs in eastern Queensland. Proc. Aust. Inst. Min. Metall., 230, 29-38.

WEBB, A.W., and McDOUGALL, I., 1968 - The geochronology of the igneous rocks of eastern Queensland. J. geol. Soc. Aust., 15(2), 313-46.

WHITE, D.A., 1962 - Clarke River, Qld - 1:250,000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes SE/55-13.

WHITE, Mary E., 1964 - 1963 plant fossil collections from the Hughenden area, Great Artesian Basin. Bur. Miner. Resour. Aust. Rec. 1964/64(unpubl.).

WHITE, Mary E., 1968 - Report on 1967 and 1963 collections of plant fossils from the Charters Towers region of Queensland. Ibid., 1968/61 (unpubl.).

WYATT, D.H., 1963 - Notes to accompany progress map of the Townsville Sheet at a scale of 1:80,000. Progress report No. 3 (1962). Geol. Surv. Qld Rep. (unpubl.).

WYATT, D.H., 1968 - Townsville, Qld - 1:250,000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes SE/55-14.

WYATT, D.H., and JELL, J.S., 1967 - Devonian of the Townsville hinterland, Queensland, Australia; in Int. Symp. on the Devonian System, Vol. I. Alberta Soc. Petrol. Geol., Calgary.

WYATT, D.H., PAINE, A.G.L., CLARKE, D.E., GREGORY, C.M., and HARDING, R.R., 1967 - The geology of the Charters Towers 1:250,000 Sheet area, Queensland. Bur. Miner. Resour. Aust. Rec. 1967/104 (unpubl.).

WYATT, D.H., PAINE, A.G.L., HARDING, R.R., and CLARKE, D.E., 1969 - Geology of the Townsville 1:250,000 Sheet area, Queensland, Bur. Miner. Resour. Aust. Rep. 127.

APPENDIX 1

PALAEONTOLOGICAL DETERMINATIONS

by

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DEVONO-CARBONIFEROUS

Collection 1 (GSQ508). Unnamed volcanics (D/Cv)

Locality: 1 mile N of Cranbourne homestead. Lat. 20°38'S, long. 146° 58'E.

Determinations: Crossopterygian fish scales cf. *Strepsodus decipiens* Woodward
Indet. palaeoniscid fish scales
Stigmaria sp.

Age: L. Carboniferous.

Collection 2 (GSQ509). Mount Hall Formation

Locality: 0.5 miles S of Rockpool Lagoon, between St Annes Cross Ra. and Suttor R. Lat. 20°58'S, long. 146°55'E.

Determinations: *Sublepidodendron* sp.
Lepidodendron sp. 'a'
Lepidodendron sp. 'b'
Stigmaria sp.

Age: Early Carboniferous

Collection 3 (GSQ504). Star of Hope Formation

Locality: About 6 miles NNW of Harvest Home homestead. Lat. 20°38'S, long. 147°6'E.

Determinations: *Lepidodendron* sp.
Stigmaria sp. indet.

Age: L. Carboniferous.

Collection 4 (GSQ507). Scartwater Formation

Locality: 8 miles W of Camp Oven Mountain. Lat. 20°23'S, long. 146°43'E.

Determination: ?*Austroclepsis* sp.

Age: Probably Carboniferous.

Collection 5 (GSQ527). Scartwater Formation

Locality: 1.6 miles NW of Cranbourne homestead. Lat. 20°31'S, long. 146°57'E.

Determinations: ?*Leptophloeum australe* (M'Coy)
Sublepidodendron sp.
Lepidodendron sp. indet.
Stigmaria aff. *ficoides* (Brongniart)
?*Elonichthys* sp.

Age: L. Carboniferous.

Collection 6 (GSQ529). Scartwater Formation

Locality: 4 miles NNE of junction of Suttor and Sellheim Rs. Lat. 20°42'S, long. 146°58'E.

Determination: *Lepidodendron* Sp. indet.

Age: Probably L. Carboniferous.

Collection 7(GSQ531). Unnamed volcanics (D/Cv)

Locality: 1.2 miles E of Pallamana homestead. Lat. 30°31'20"S, long. 146°32'40"E.

Determination: Indet. equisetalean plant

Age: Probably L. Carboniferous.

Collection 8 (GSQ532). Star of Hope Formation

Locality: Mt Elsie homestead. Lat. 20°59'S, long. 146°34'E.

Determinations: *Lepidodendron* sp.
Indet. plant fragments

Age: L. Carboniferous

Collection 9 (GSQ 533). Star of Hope Formation

Locality: Bumble Ginnie Waterhole, 4 miles SE of Nosnillor homestead. Lat. 20°59'S, long. 146°23'E.

Determinations: *Leptophloeum australe* (M'Coy)
Indet. lepidodendroid plant
'Wood' of lepidodendroid plant

Age: U. Devonian or L. Carboniferous.

Collection 10 (GSQ528). Unnamed volcanics (D/Cv)

Locality: 3.8 miles SE of Pallamana homestead. Lat. 20°34'S, long. 146°34'E.

Determinations: Lepidodendron sp. indet.
Indet. equisetalean plant

Age: Probably L. Carboniferous.

Discussion

Collection 1 includes a quantity of large (22 x 25 mm) plate-like cycloidal fish scales. The scales, which were originally deeply imbricate, are ornamented by fairly coarse radial striae bearing closely spaced minute tubercles, together with concentric growth lines on the exposed sector, and extremely fine striae and concentric growth lines on the attached portions. Some bone fragments are also present but are too incomplete for identification. Scales of this type are found in Crossopterygian fish of the family Osteolepidae, which are known from freshwater deposits of Devonian and Carboniferous age. The present material compares closely with the scales of Strepsodus decipiens described by Woodward (1906) from Lower Carboniferous strata at Mansfield, Victoria, but precise determination is impossible from scales alone. The association with Stigmaria would support a Lower Carboniferous age for the collections.

The plant referred to Sublepidodendron sp. in collection 2 is closely comparable with material collected by D.H. Wyatt from the Townsville 1:250,000 Sheet, and Sublepidodendron is considered to be restricted to the late Devonian and early Carboniferous. Specimens of Lepidodendron sp. 'a' are deeply decorticated, but leaf cushions are the largest I have seen in collections from Queensland - approximately 7 mm wide by 35 mm long. The assemblage is typical of the early Carboniferous.

Lepidodendron sp. in collection 3 is similar, particularly in the form of the leaf cushions and surface marking on the interstitial areas, to specimens from DTS3 (L. 90) reported by Woods (1961, unpubl.) from beds above the Myrtlevale Beds in the Townsville Sheet area, where it is also associated with Stigmaria sp.

Collection 4 contains a number of pieces of a silicified plant in a remarkably fine state of preservation. The material comprises a great number of closely appressed, parallel root protosteles (1.5-3 mm diameter) with triarch or more frequently tetrarch protoxylem and metaxylem with scalariform thickening, surrounded by a dark endodermis and wide cortex, thickened in its outer zones. These roots are packed so closely that smaller steles become very deformed and root hair development seems to be completely lacking. Branching does occur, the offshoot arising from the endodermal layer. The material is believed to represent part of the outer adventitious root zone in the 'false trunk' of an early fern-like plant. No stem or leaf trace steles are present in the samples. Only two genera of fossil fern-like plants with 'false trunks' are known - Austroclepsis Sahni from the Carboniferous (Kuttung Series) of New South Wales and Tempskya Corda from the Cretaceous of Europe and North America. Precise identification is impossible without stem material, but closest affinities are probably with Austroclepsis australis (Osborn), although, like Tempskya, root protoxylem in this plant has been shown by Sahni (1929) to be uniformly diarch.

In collection 5, Leptophloeum australe is only tentatively identified, as the plant is decorticated to the Knorria condition. Fragments of a palaeoniscoid fish, possibly Elonichthys, are extremely abundant in the collection and include ridged scales, maxillae, and preopercula. The association of Sublepidodendron, Lepidodendron, and the Elonichthys-like fish is indicative of a Lower Carboniferous age.

The silicified 'wood' in collection 9 is essentially undifferentiated cortical or peridermal tissue, in which small cells are arranged in radial series. It is probably part of the trunk of a lepidodendroid plant. Compression prior to silicification has resulted in the collapse of the material, with virtual destruction of original structure.

Collection 10 includes the stems of a small, probably herbaceous equisetalean plant. The stems are slender (approximately 4 mm diameter), with closely spaced nodes, no more than 1 mm apart; no foliage is preserved. The plant is present also in collection 7, which must have been derived from a similar horizon.

CAINOZOIC

Sellheim Formation

Locality: SE corner of Rishton Scrub. Lat. 20°10'S, long. 146°33'E.

Determinations: Pataloxylon sp.

Age: Cainozoic.

Discussion

The three wood samples submitted are all poorly preserved, but enough can be seen of the structure to suggest generic identity at least.

In transverse section, winter wood is marked by vessels occurring singly or in pairs with their apposed surfaces flattened; in spring and summer wood they occur in groups of two and three. Vessels are characterized by simple reticulate pitting of the walls. Xylem parenchyma cells are very small and moderately thickened; wood fibres are larger in diameter and are closely associated with the vessels. Medullary rays are 6 to 10 cells deep, uniseriate or biseriate, but more frequently the former, and in transverse section markedly sinuate. The wood, which is that of a dicotyledonous angiosperm, is placed in the form genus Pataloxylon described by Sahni (1920). Woods of this type are regarded as Cainozoic in age.

Tertiary Sandstone

Locality: 5 miles NW of Cranbourne homestead. Lat. 20°37'S, long. 146°54' 20"E.

Determinations: Dicotyledonous angiosperm wood.

Age: Cainozoic.

Discussion

Dicotyledonous angiosperm wood in the collection cannot be identified readily even to generic level, but a Cainozoic age is certainly indicated. None of the specimens appears to be identical with wood collected from the Sellheim Formation at latitude 20°10'S., longitude 146°33'E.

References

SAHNI, B., 1920 - Petrified plant remains from the Queensland Mesozoic and Tertiary formations. Geol. Surv. Qld Publ. 267, 1-48.

SAHNI, B., 1929 - On *Clepsidropsis australis*, a zygopterid tree-fern with a *Tempskya*-like false stem, from the Carboniferous rocks of Australia. Phil. Trans. Roy. Soc. London, 217B, 1-38.

WOODS, J.T., 1961 - Preliminary notes on collections DTS 3 and DTS 4 referred to in District Geologist's memorandum of 11th July, 1961. Geol. Surv. Qld Rep. (unpubl.).

WOODWARD, A.S., 1906 - On a Carboniferous fish fauna from the Mansfield district, Victoria. Mem. Nat. Mus. Vic., 1, 1-23.

APPENDIX 2

ISOTOPIC AGE DETERMINATIONS

By

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Rock Unit (map symbol)	BMR No.	ANU No.	Military Grid Reference E.	Military Grid Reference N.	Rock Type	Material Analysed	Method	Age ($\times 10^6$ yrs)	Remarks
Nulla Basalt	F55/2/1	GA 1145	373300	2494000	Olivine basalt	Whole rock	K/Ar	4.0± 2.0	
Nulla Basalt	2	GA 1145	354600	2486600	Olivine basalt	Whole rock	K/Ar	1.30±0.1	
Nulla Basalt	12	GA 5570	351900	2488400	Olivine basalt	Whole rock	K/Ar	1.24±10%	
Tuckers Igneous Complex	30	GA 5794	466800	2491400	Biotite granodiorite	Biotite	K/Ar	277)	
Tuckers Igneous Complex	32	GA 5795	460200	2487500	Hornblende-biotite granodiorite	Biotite	K/Ar	282))	Age of intrusion about 280 m.y.
Tuckers Igneous Complex	33	GA 5796	460700	2488800	Biotite-quartz gabbro	Biotite	K/Ar	277))	
Boori Igneous Complex	34	GA 5797	482000	2488200	Biotite-quartz diorite	Biotite	K/Ar	278))	
Dyke	13	GA 5561	434000	2485300	Hornblende porphyrite	Hornblende	K/Ar	328))	
Dyke	38	GA 5720	434000	2485300	Hornblende porphyrite	Hornblende	K/Ar	339))	Age of intrusion about 300 m.y.
Dyke	39	GA 5721	434700	2488500	Hornblende porphyrite	Hornblende	K/Ar	332))	
Lolworth Igneous Complex	9	GA 5598	356200	2470800	Garnetiferous muscovite granite	Whole rock	Rb/Sr	Ø))	
Lolworth Igneous Complex	10	GA 5285	355600	2473000	Garnetiferous muscovite granite	Whole rock	Rb/Sr	Ø))	Refer to Hughenden Sheet (BMR Report

Rock Unit (map symbol)	BMR No.	ANU No.	Military Grid Reference E.	N.	Rock Type	Material Analysed	Method	Age (x10^{6}yrs)	Remarks
Lolworth Igneous Complex	10	GA 5285	355600	2473000	Garnetiferous muscovite granite	Muscovite	K/Ar	401))	126)
Barrabas Adamellite	22	GA 5709	498100	2476600	Biotite adamellite	Whole rock	Rb/Sr	X)	
Barrabas Adamellite	23	GA 5710	494900	2477600	Biotite adamellite	Whole rock	Rb/Sr	N)	K/Ar and Rb/Sr ages
Barrabas Adamellite	23	GA 5710	494900	2477600	Biotite adamellite	Biotite	K/Ar	397)	concordant
Ravenswood Granodiorite Complex (O-Da)	3	GA 5703	384000	2465500	Granite	Whole rock	Rb/Sr		Analysis fits neither 454 nor 394-m.y. isochron
Ravenswood Granodiorite Complex (O-Da)	4	GA 5704	358000	2450600	Granite	Whole rock	Rb/Sr	) N)	This age is dependent on the assumption that
Ravenswood Granodiorite Complex (O-Da)	6	GA 5705	346900	2421600	Granite	Whole rock	Rb/Sr	) N))	the initial $^{87}Sr/^{86}Sr$ ratio of samples 4 and 6 was 0.7053
Ravenswood Granodiorite Complex (O-Dk)	28	GA 5713	477100	2488900	Biotite granite	Whole rock	Rb/Sr	*	
Ravenswood Granodiorite Complex (O-Dk)	28	GA 5713	477100	2488900	Biotite granite	Biotite	K/Ar	397	K/Ar age due to Ar leakage during 394-m.y. phase of intrusion
Ravenswood Granodiorite Complex (O-Di)	19	GA 57-7	496100	2489700	Leucogranite	Whole rock	Rb/Sr	*	
Ravenswood Granodiorite Complex (D-Dm)	24	GA 5711	492400	2483000	Biotite granodiorite	Whole rock	Rb/Sr	*	
Ravenswood Granodiorite Complex (O-Dg)	20	GA 5708	496600	2487500	Biotite granodiorite	Whole rock	Rb/Sr	*	

Rock Unit (map symbol)	BMR No.	ANU No.	Military Grid Reference E.	N.	Rock Type	Material Analysed	Method	Age ($x10^6$yrs)	Remarks
Ravenswood Granodiorite Complex (O-Dg)	26	GA 5712	485600	2493500	Hornblende-biotite granodiorite	Whole rock	Rb/Sr	*	
Ravenswood Granodiorite Complex (O-Dg)	26	GA 5712	485600	2493500	Hornblende-biotite granodiorite	Hornblende	K/An	426	K/Ar age due to partial Ar leakage during 394-m.y. phase
Ravenswood Granodiorite Complex (O-Dr)	16	GA 5706	505750	2482400	Granodiorite	Hornblende	Rb/Sr	N̸	
Ravenswood Granodiorite Complex (O-Dr)	27	GA 5799	501500	2483800	Quartz diorite	Hornblende	Rb/Sr	N̸	
Ravenswood Granodiorite Complex (O-Dr)	37	GA 5735	425000	2475000	Granodiorite	Whole rock	Rb/Sr	N̸	
Ravenswood Granodiorite Complex (O-Dr)	37	GA 5735	525000	2475000	Granodiorite	Biotite	K/Ar	) 396)	K/Ar and Rb/Sr ages concordant
Ravenswood Granodiorite Complex (O-Dr)	37	GA 5735	425000	2475000	Granodiorite	Horbnlende	K/Ar	) 404)	

Notes: Analytical error in individual K/Ar determinations is $\pm$ 3%, unless otherwise stated.

Rb/Sr isochrons: * 454 $\pm$ 30 m.y.; N̸ 394 $\pm$ 30 m.y.; Ø 401 $\pm$ 7 m.y.

APPENDIX 3

STRATIGRAPHIC DEFINITIONS OF ROCK UNITS MAPPED IN THE RAVENSWOOD 1-MILE SHEET AREA IN 1966

by

D.E. Clarke

GLENELL GRANODIORITE

Derivation of Name: Glenell South Holding, near Ravenswood.

Type Locality and Distribution: Elbow Mill, E.496500, N.2487500. 30 square miles between Silver Valley homestead and Ravenswood; extends north into Townsville Sheet area, but not recognized in course of mapping Townsville Sheet area.

Lithology: Medium-grained porphyritic hornblende-biotite granodiorite.

Relationships: Subunit of Ravenswood Granodiorite Complex. Intrudes main granodiorite phase of complex; intruded by Mosgardies Adamellite and Millaroo Granite.

Age: 454 $\pm$ 30 m.y. by Rb/Sr whole rock isotopic dating.

MOSGARDIES ADAMELLITE

Derivation of Name: Mosgardies Creek, 3 miles west of Ravenswood.

Type Area and Distribution: Area drained by right hand branch of Barrabas Creek, between E.492300, N.2483400 and E.493000, N.248600. Occupies belt 6 miles long and up to 2 miles wide centred 7 miles west of Ravenswood.

Lithology: Medium-grained porphyritic biotite adamellite, some microgranite.

Relationships: Subunit of Ravenswood Granodiorite Complex. Intrudes main granodiorite phase of complex, and Glenell Granodiorite.

Age: 454 $\pm$ 30 m.y. by Rb/Sr whole rock isotopic dating.

KIRKLEA GRANITE

Derivation of Name: Kirklea Holding, west of Ravenswood.

Type Area and Distribution: Southern end of range between Little Oaky Creek and Pandanus Creek, centred on Himalaya mine (E.476200, N.2490400). Forms two low ranges between Pandanus Creek and Kirk River.

Lithology: Medium to coarse calc-alkali biotite granite.

Relationships: Subunit of Ravenswood Granodiorite Complex. Intrudes main granodiorite phase of the complex.

Age: 454 ± 30 m.y. by Rb/Sr whole rock isotopic dating.

MILLAROO GRANITE

Derivation of Name: Millaroo Holding, near Ravenswood.

Type Area and Distribution: Banana Creek, north of Ravenswood. 40 square miles north of Ravenswood; country about 400 feet higher than that developed on main granodiorite phase. Extends north into Townsville Sheet area, but not recognized in course of mapping Townsville Sheet area.

Lithology: Calc-alkali granite and adamellite.

Relationships: Subunit of Ravenswood Granodiorite Complex. Intrudes main granodiorite phase of complex, Kirk River Beds, Mount Windsor Volcanics, Glenell Granodiorite.

Age: 454 ± 30 m.y. by Rb/Sr whole rock isotopic dating.

BARRABAS ADAMELLITE

Derivation of Name: Barrabas Creek.

Type Locality and Distribution: Between Elphinstone and Connolly Creeks, centred about locality E.497000, N.2476000. Forms east-west trending mass, 7 by 3 miles, centred 6 miles southwest of Ravenswood.

Lithology: Biotite adamellite and granodiorite.

Relationships: Intrudes main granodiorite phase of Ravenswood Granodiorite Complex.

Age: 394 ± 30 m.y. by Rb/Sr whole rock isotopic dating.

TUCKERS IGNEOUS COMPLEX

Derivation of Name: Tuckers Range, between Charters Towers and Ravenswood.

Type Area and Distribution: Northwest side of range, between Black Soil Mill (E.46900, N.2492400) and Copper Pinnacle (E.457500, N.2486700). Forms Tuckers Range, about 15 square miles.

Lithology: Four subunits: (1) gabbro and diorite, (2) granodiorite and tonalite, (3) granodiorite, (4) leucogranite (youngest).

Relationships: Intrudes Ravenswood Granodiorite Complex and unnamed Upper Carboniferous(?) volcanics.

Age: 280 ± 8 m.y. by K/Ar isotopic dating of biotite.

BOORI IGNEOUS COMPLEX

Derivation of Name: Boori Holding, west of Ravenswood.

Type Area and Distribution: Within 1 mile radius of Mt Kirk (E.487000, N.2485400). Forms Kirk Range, between Charters Towers and Ravenswood.

Lithology: Three subunits: (1) Leucogranite, (2) tonalite and diorite, (3) granodiorite and adamellite (youngest).

Relationships: Intrudes Ravenswood Granodiorite Complex and unnamed Upper Carboniferous(?) volcanics.

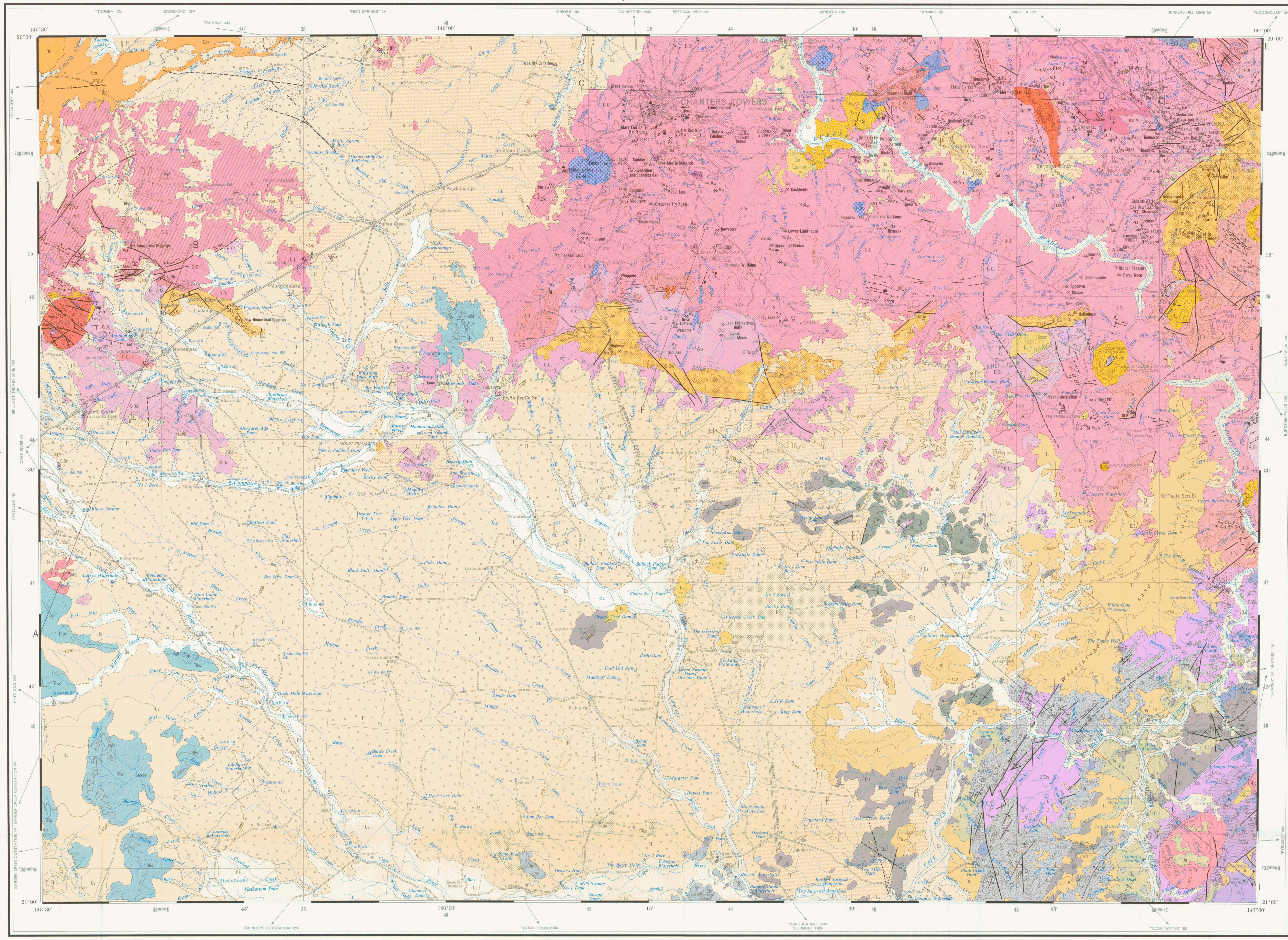
Age: 280 $\pm$ 8 m.y. by K/Ar isotopic dating of biotite.

AUSTRALIA 1:250,000 GEOLOGICAL SERIES

CHARTERS TOWERS

QUEENSLAND

SHEET SF 55-2



Reference

- Geological boundary
- Anticline
- Syncline
- Fault, showing relative horizontal movement
- Lineament (air-photo interpretation)
- Where location of boundaries, folds and faults is approximate, line is broken; where inferred, queried; where concealed, boundaries and folds are dotted, faults are shown by short dashes
- Strike and dip of strata
- Prevailing strike and dip of strata
- Vertical strata
- Horizontal strata
- Overturned strata
- Dip<15°, Trend lines, Joint pattern, Horizontal strata — air-photo interpretation
- Strike and dip of foliation
- Vertical foliation
- Strike and dip of cleavage
- Vertical cleavage
- Plunge of lineation
- Strike and dip of foliation with plunge of lineation
- Inclined platy flow
- Vertical platy flow
- X22 Measured section with reference number
- Macrofossil locality, Plant fossil locality, Fossil wood — with text reference e.g. C4 or GAB 1068
- 11 Sample locality for isotopic age-determination
- Dyke or vein; a–aplite, ad–adamellite, an–andesite, bp–biotite pegmatite or aplite, br–intrusion breccia, d–dolerite, microdiorite, di–diorite, f–felsite (mainly rhyolite), g–granite, gb–gabbro, mg–microgranite, p–quartz-feldspar porphyry, po–hornblende porphyrite, q–quartz. Absence of letter symbol indicates photo-interpretation
- KIRK Old mining township
- Abandoned mine
- Abandoned alluvial diggings
- Prospect
- Battery
- Abandoned battery
- •Ba Minor mineral occurrence
- Ag Silver
- Au Gold
- Ba Barytes
- Bi Bismuth
- Cu Copper
- Mo Molybdenum
- Ms Magnesite
- Mt Magnetite
- Pb Lead
- Py Pyrite
- Sb Antimony
- Z Zinc
- Water bore
- E Earth tank or dam
- Windpump
- Dam on stream
- WH Waterhole on stream
- Swamp
- 1000 Topographic contour; interval: 500 feet
- 750 Intermediate contour
- Highway
- Road
- Vehicle track
- Railway with station and siding
- Fence
- Telephone line
- "Egera" Homestead
- Hut
- Yd Yard
- Airport
- Landing ground
- Astronomical station
- Trigonometrical station
- • 740′ Spot elevation in feet, instrument levelled; datum: mean sea level
- PD Position doubtful

Reference

CAINOZOIC	QUATERNARY		Qa	Alluvium
			Qs	Superficial sand, silt and gravel
		Toomba Basalt	Qt	Vesicular olivine basalt
	PLEISTOCENE	Sellheim Formation	Qe	Semi-consolidated argillaceous sandstone, ferruginous sandstone, pebble conglomerate
			Qg	Semi-consolidated alluvial and outwash deposits
			Qo	Grey and brown soils
	UPPER PLIOCENE TO PLEISTOCENE	Nulla Basalt	Czn	Olivine basalt
	TERTIARY	Campaspe Beds	Tf	Ferricrete (only recognisable on Campaspe Beds)
			Tc	Buff argillaceous sandstone; some conglomerate, siltstone and claystone
			Tl	Laterite
			Tu	Argillaceous sandstone, feldspathic sandstone, pebbly sandstone and conglomerate, minor siltstone and claystone
MESOZOIC	LOWER TRIASSIC	Warang Sandstone	Rlw	White kaolinitic quartz sandstone; minor red and white siltstone
PALAEOZOIC	UPPER PERMIAN	Mundic Igneous Complex	Pum_3	Drusy leucogranite
			Pum_2	Minor intrusives ranging from dolerite to microgranite
			Pum_1	Volcanic breccia; some dacite and rhyolite
		Betts Creek Beds	Pub	Lithic sandstone and mudstone, in places tuffaceous; quartzose conglomerate
	UPPER CARBONIFEROUS TO LOWER PERMIAN		C-Pg	Granodiorite, adamellite, leucogranite
			$C\text{-}Pg_1$	Biotite adamellite
			C-Py	Rhyolite, rhyolite breccia
			C-Pi	Altered diorite, gabbro, dolerite
		Boori Igneous Complex	$C\text{-}Pb_3$	Biotite-hornblende granodiorite, adamellite
			$C\text{-}Pb_2$	Tonalite, minor diorite
			$C\text{-}Pb_1$	Leucogranite
		Tuckers Igneous Complex	$C\text{-}Pt_4$	Leucogranite, leucoadamellite
			$C\text{-}Pt_3$	Granodiorite, minor adamellite
			$C\text{-}Pt_2$	Biotite-hornblende granodiorite, minor tonalite
			$C\text{-}Pt_1$	Gabbro, diorite, mangerite, minor granodiorite
	UPPER CARBONIFEROUS		Cur	Intrusive rhyolite, quartz-feldspar porphyry and quartz porphyry; minor dacite, trachyandesite, andesite and intrusive rhyolite breccia
			Cuv	Rhyolite, agglomerate, andesite, tuff, volcanic breccia; minor labile conglomerate and finer sediments
	LOWER CARBONIFEROUS	Drummond Group: Natal Formation	Cln	Alternating fine feldspathic quartz sandstone and olive siltstone. Poorly preserved plant material
		Drummond Group: Bulliwallah Formation	Clb	Fine to medium feldspathic quartz sandstone; minor olive mudstone, pebbly feldspathic quartz sandstone and algal limestone. Poorly preserved plant material
		Drummond Group: Star of Hope Formation	Cls	Lapilli tuff, welded tuff, tuffaceous sandstone, volcanolithic sandstone, sandstone with quartz pebbles, conglomerate. Plant fossils
		Drummond Group: Raymond Formation	Clr	Fine to medium quartz sandstone, locally feldspathic; interbeds of clayey sandstone and mudstone. Plant fossils
		Drummond Group: Mount Hall Formation	Clh	Pebbly and conglomeratic quartz sandstone, coarse quartz sandstone. Wood fragments
	UPPER DEVONIAN? TO LOWER CARBONIFEROUS	Drummond Group: Scartwater Formation	D/Cw	Fine feldspathic sandstone with interbeds of calcarenite, algal limestone, olive mudstone, lithic tuff and tuff. Plant fossils
		Saint Anns Formation	D/Ca	Acid and intermediate volcanics and algal limestone at top; labile sandstone; minor green mudstone and phosphatic sandstone. Plant fossils
			D/Cv	Acid and intermediate volcanics; some micaceous labile arenite
	MIDDLE DEVONIAN	Ukalunda Beds	Dk	Phyllite, siltstone, fine greywacke
			Pzo	Rhyolitic and dacitic porphyry; agglomerate
	UPPER SILURIAN OR LOWER DEVONIAN	Lolworth Igneous Complex	S-Dl	Banded pegmatitic and aplitic garnetiferous muscovite granite and adamellite; minor massive biotite adamellite
		Barrabas Adamellite	S-Db	Biotite adamellite and granodiorite; some biotite granite. Later phase of leucoadamellite and microgranite
	MIDDLE ORDOVICIAN AND UPPER SILURIAN OR LOWER DEVONIAN	Ravenswood Granodiorite Complex	O-Da	Pink and red biotite granite and adamellite, microgranite, biotite pegmatite and aplite. Foliated in places
		Ravenswood Granodiorite Complex: Kirklea Granite	O-Dk	Leucocratic biotite granite
		Ravenswood Granodiorite Complex: Millaroo Granite	O-Di	Leucocratic biotite granite and adamellite; microgranite
		Ravenswood Granodiorite Complex: Mosgardies Adamellite	O-Dm	Porphyritic adamellite, granite, microgranite
		Ravenswood Granodiorite Complex: Glenell Granodiorite	O-Dg	Porphyritic hornblende-biotite granodiorite
			O-Do	Olivine gabbro, leucogabbro, hornblendite, diorite, quartz monzonite
			O-Dd	Quartz diorite, diorite
			O-Dr	Hornblende-biotite granodiorite and tonalite; minor adamellite, gabbro and diorite southwest of Burdekin River. Foliated in places
	CAMBRIAN TO ORDOVICIAN	Kirk River Beds	€-Ok	Micaceous shale, siltstone, feldspathic sandstone, greywacke
		Charters Towers Metamorphics	€-Of	Mica schist, quartzite, quartz-feldspar-biotite schist, hornblende schist; cordierite, andalusite and staurolite hornfelses; chlorite schist, marble
		Cape River Beds	€-Oc	Schist, quartzite, phyllite, metavolcanics; siltstone, mudstone, arenite, pyritic shale, minor tuff; rare marble and calc-silicate hornfels
		Mount Windsor Volcanics	€-Ow	Acid to intermediate volcanics, hornfels, schist, rare labile sediments

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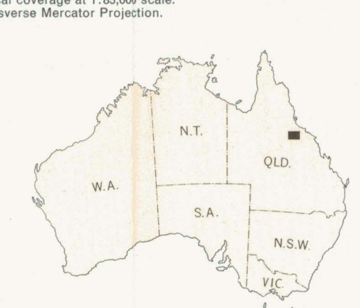
Transverse Mercator Projection.



INDEX TO ADJOINING SHEETS

Showing Magnetic Declination

GEORGETOWN SE 54-12	EINASLEIGH SE 55-9	INGHAM SE 55-10		
GILBERTON SE 54-16	CLARKE RIVER SE 55-13	TOWNSVILLE SE 55-14	AYR SE 55-15	
RICHMOND SF 54-4	HUGHENDEN SF 55-1	CHARTERS TOWERS SF 55-2	BOWEN SF 55-3	PROSERPINE SF 55-4
MANUKA SF 54-8	TANGORIN SF 55-5	BUCHANAN SF 55-6	MOUNT COOLON SF 55-7	MACKAY SF 55-8
WINTON SF 54-12	MUTTABURRA SF 55-9	GALILEE SF 55-10	CLERMONT SF 55-11	SAINT LAWRENCE SF 55-12

ANNUAL CHANGE 2′E

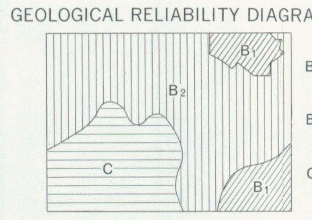
Scale 1:250,000

5 0 5 10 15 MILES

5 0 5 10 15 20 25 KILOMETRES

GREY NUMBERED LINES INDICATE THE 20,000 YARD TRANSVERSE MERCATOR GRID, ZONE 7 (AUSTRALIA SERIES)

GEOLOGICAL RELIABILITY DIAGRAM



- B_1 Detailed reconnaissance, with numerous traverses
- B_2 Reconnaissance, with air-photo interpretation
- C Mainly air-photo interpretation

Geology, 1963-64 and 1966-67, by D. E. Clarke, D. H. Wyatt (G.S.Q.), A.G.L. Paine, R. R. Harding, C. M. Gregory, F. Olgers, J. G. Binnekamp, R. R. Vine (B.M.R.).
Compiled, 1963-68, by A. G. L. Paine (B.M.R.), D. E. Clarke (G.S.Q.), J. L. McGovern, A. Tatarow, R. A. Swoboda, R. Pitschel (B.M.R.) W. J. Rowland (Queensland Mines Department).
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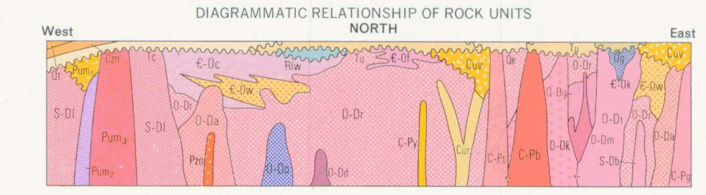
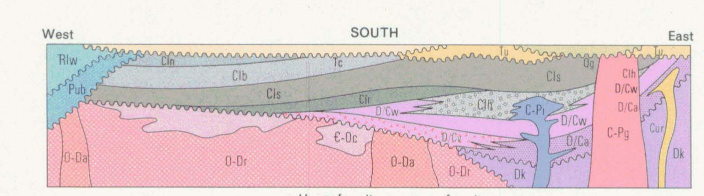
DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS

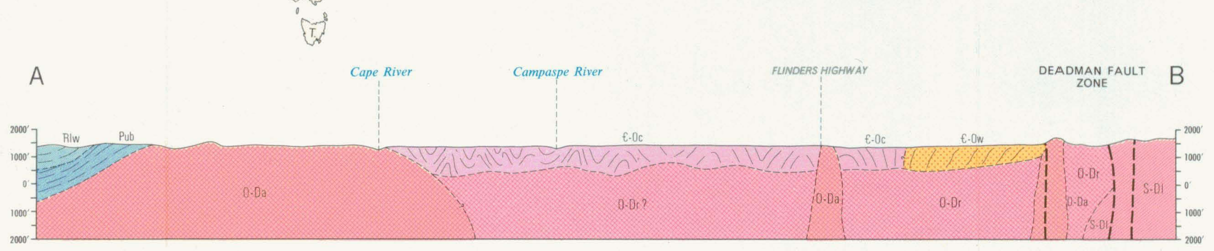


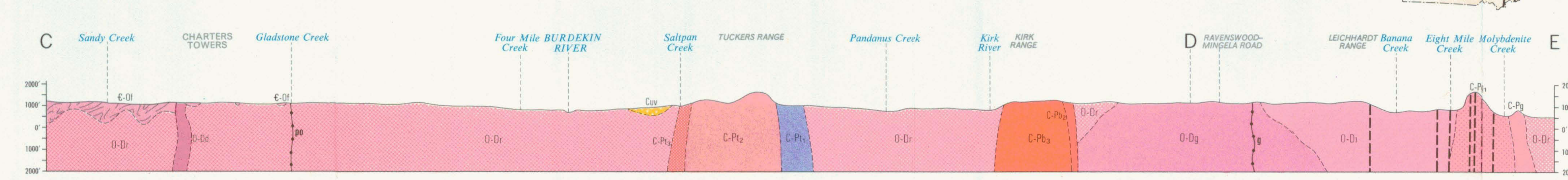


Unconformity or nonconformity

Sections

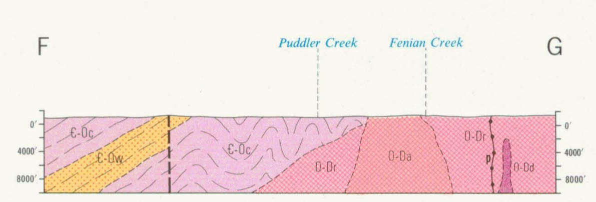
Cainozoic sediments omitted from sections
Attitude of faults not known
Scale: $\frac{V}{H} = 4$

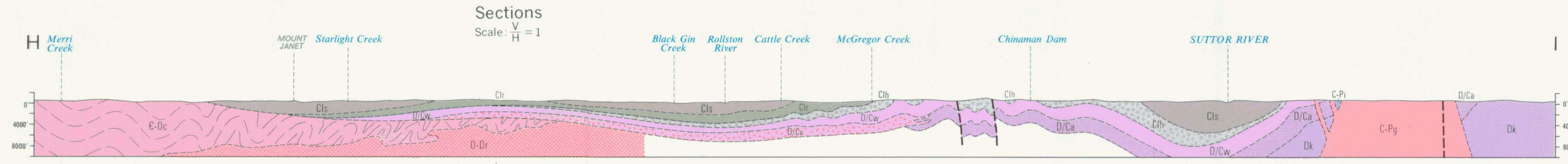




Sections

Scale: $\frac{V}{H} = 1$





FIRST EDITION 1969

CHARTERS TOWERS

SHEET SF 55-2

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